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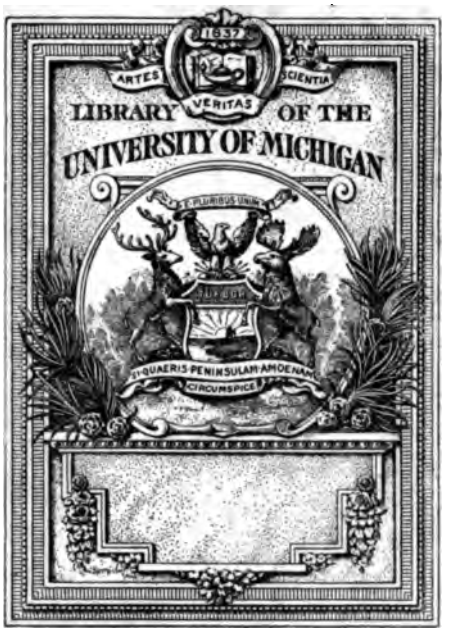
NATURAL HISTORY OF HAWAII

William Alanson Bryan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Natural History of Hawaii

BOOK ONE

THE PEOPLE, THE ISLANDS AND THE PLANT LIFE OF THE GROUP

Wm. Hanson Bryan

Frontispiece

"There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy."—*Shakespeare*.

Natural History of Hawaii

Being an Account of the Hawaiian People, the Geology and Geography of the Islands, and the Native and Introduced Plants and Animals of the Group

BY

WILLIAM ALANSON BRYAN, B. Sc.
Professor of Zoölogy and Geology in the College of Hawaii

Fellow of the American Association for the Advancement of Science; Member, The American Ornithologists Union; National Geographic Society; American Fisheries Society; Hawaiian Historical Society; Hawaiian Entomological Society; American Museums Association; National Audubon Society; Seven Years Curator of Ornithology in the Bishop Museum, etc.

Illustrated with one hundred and seventeen full page plates from four hundred and forty-one photographs elucidating the ethnology of the native people, the geology and topography of the islands and figuring more than one thousand of the common or interesting species of plants and animals to be found in the native and introduced fauna and flora of Hawaii.

Honolulu. Hawaii
The Hawaiian Gazette Co., Ltd.
1915

For Distributors see Index

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Honolulu

TO THE MEMORY OF

R. G. B.

THIS VOLUME IS DEDICATED

PREFACE.

In the preparation of the following pages it has been the aim of the author to bring together into one volume the more important and interesting facts about the Hawaiian Islands and their primitive inhabitants, as well as information concerning the native and introduced plants and animals of the group.

It is believed that those who read this volume—be they travelers, residents or students—will find, in its brief account of nature in Hawaii, not only much that will prove interesting and entertaining, but that which will foster and stimulate an interest in the things of nature for which these mid-ocean islands are far-famed.

It is asserted that, in childhood, every person is interested in some of the many fields of natural history. It would be strange, indeed, if Hawaii, with its wonderful natural environment and remarkable tropical plants and interesting animals. did not rekindle in the minds of the old and encourage in the hearts of the young a desire to know more about things Hawaiian. As a result of the natural longing for information, there has existed for years a pressing demand in Hawaii, from teachers, travelers and students, for a hand-book that would supply the names for, as well as the facts relative to, familiar objects.

To supply a guide that would provide reliable and readable information, in a form that would be welcomed by the general reading public, and, at the same time, that would meet the requirements of the homes, the schools, and the libraries of Hawaii and the mainland, as a convenient reference book, has been the author's endeavor. While the volume lays no claim to being an exhaustive monograph of the vast subject of which it treats, the material used has been patiently gathered from every possible source and carefully selected, sifted and verified in the field and study, by the author, during many years' residence in the islands as an enthusiastic naturalist, museum curator and college professor. For these reasons it is believed that specialists with technical information at hand, no less than those who pride themselves on their general knowledge of things Hawaiian, will find the volume a handy 'first aid' and reliable and convenient reference work.

The carrying out of the three-fold object of preparing a readable account of Hawaii, a text-book or supplementary reader on the natural history of the islands, and a convenient reference book for those who require a more technical or detailed handling of the material included than is customary in a book frankly popular in nature, presents certain difficulties that seem to have been met by the selection, classification, and arrangement of the text and the illustrations.

The casual reader will find the body of the text shorn of the technical verbiage and scientific names that so often distract, annoy and fatigue the layman. Where such terms have been indispensable they have been defined in the

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text, the footnotes, or in the index and glossary. Those who prefer their reading should rest on the firmer ground that definite nomenclature is supposed to impart, will find the necessary technical names of orders, families, genera and species, referred to in the text given in the footnotes, or in the cross-references in the index. The systematist and specialist will not expect the degree of completeness in this regard that would characterize a manual dealing with any one of the subjects herein treated. However, the scientific worker will find in the index and glossary, not only the scientific names most frequently in use for common objects in the more important contributions to the literature of his subject in the islands, but often the latest word on the nomenclature of the species in question.

The index and glossary is made a special feature of the book. It has been carefully prepared and numerous cross-references to the various English, Hawaiian and Latin names that are current with the people, or are written into the literature of the islands will aid the student in working out synonyms. The author has endeavored to make the possession of a little information, concerning the natural history of Hawaii, of use to the would-be student. To aid the layman, two generous open doors have been provided: one through the index, the other through the table of contents. By the use of these doors the inquirer, in possession of any one of the many common names, the name of the great division to which the plant or animal belongs, or even knowing something of its habits or habitat, will, in most cases, find their knowledge sufficient to guide the way to such definite information as may be contained within the body of the book.

Much in the form of notes, comments and observation that seemed too specific, local, critical, fragmentary or prosaic to fit well into the plan of the body of the text, has been reserved for the combined index, glossary and compendium at the end of the volume, and there appears in alphabetical order without reference to the text. The index therefore should be in constant use by the reader and student.

Because of obvious limitations, and owing to the nature of the objects sought, the author has made no rigid attempt to follow out a system of arrangement in this volume such as an ethnologist, a geologist, a botanist or a zoölogist would choose were they treating their special subject separately and in fuller detail. Strictly rigorous adherence to the various chapter headings has often been next to impossible. A given subject is often presented in preceding and succeeding chapters; or it may occur in different parts of the book. The natural desire is that books, in any way scientific in character, should follow some generally accepted system or arrangement. Such systems usually start with the lower, older, simpler or more generalized form and proceed gradually to the consideration of the more recent, higher or complex. Occasionally, however, for the sake of convenience, the system is reversed and a different order of arrangement may be followed. In the following pages the arrangement of the material has been based largely on a certain association of ideas and objects; but the sequence of the chapters has been controlled, to a

certain degree, by expediency or caprice. Even in the arrangement of the five main sections into which the book is divided, it has seemed expedient to place that part first which, in a rigid natural order, would logically have been placed near the last. Nevertheless it will require no great intelligence on the part of the reader to trace out for himself the historical sequence of nature in Hawaii. No doubt the first great event would be the formation of the islands, followed by their occupation by plants and animals. These events in the natural order, and according to system, would doubtless long precede the peopling of the islands by the Hawaiian race, or the introduction, by them or any other race, of the various foreign plants and animals found in the group.

The intimate relation which existed between the splendid native Hawaiian people and their isolated environment is a subject of the greatest interest and entitles the human inhabitants to first consideration in the present treatment of this subject. The character and natural history of the race and the use made by the people in their economy, arts and practices, of the various materials furnished them by nature, unites them most closely with their environment; and in a natural history, such as this, calls for an acquaintance with the Hawaiian race, as a native people and the aboriginal inhabitants of the country, before we consider the environment which they had so thoroughly explored and mastered long before their contact with Europeans.

It is confidently believed that the all too brief account of the ancient Hawaiian people is one that will instill a just pride of ancestry into the hearts of those readers whose forebears were of the native Hawaiian race. Not so many hundred years ago, the ancestors of the proudest Europeans were little more than aborigines, and ate nuts and herbs, and depended on the fortunes of the chase for their meat. Not so many centuries before that, as the world measures time, a collection of their handiwork would have shown a group of objects far more crude than were those possessed by the Hawaiians at the time of their meeting with a dominant and powerful race.

It seems hardly necessary to say that the following pages are not offered primarily as an original contribution to the natural history of Hawaii. The task has been chiefly to bring together information about the islands that only an expert knows where to find. That which has suited the author's purpose has often been taken almost verbatim from the most available, which in many cases has been the original source.

From the writings of the many experts who have studied the various fields the natural history of Hawaii affords, the author in his own reading has culled wherever anything was found that would help to make this book more complete or interesting. The fruitful fields have been many, and to workers, past and present, whoever they may be, the author gladly makes the fullest acknowledgments. It is owing to the efforts of all that this general treatment of nature in Hawaii is made possible. In many cases where it has been necessary to trace material to its original source, so much has been found that had been borrowed without acknowledgment—even in the writings of our most punctilious scient-

ists—that to give full and proper credit for information on Hawaiian subjects would involve a searching and comparing of original sources, that would profit but little, and would add endless labor to an already heavy task.

So as the teller of an old tale the author makes no elaborate attempt to enumerate his sources and burden his book with an extended bibliography. No one however can, without flagrant injustice, write upon any Hawaiian theme without acknowledging his indebtedness to Mr. Thomas G. Thrum, who for more than forty years has been steadily engaged in gathering, compiling and publishing data on every phase of the Hawaiian Islands. His forty Annuals constitute a mine of information of which these islands are justly proud.

In the body of the text effort has been made to indicate the chief source and give credit for noteworthy facts, but the author wishes especially in this connection to allude to his colleagues and fellow workers in the field of science, who have generously given every assistance in their power in a spirit of willing coöperation that has made a pleasure of what would otherwise—and but for the love of the thing—have been a tedious and thankless task.

In order that these pages might carry the additional weight of specific authority the author has read the manuscript of the various chapters to specialists who have distinguished themselves in their chosen fields, and has incorporated their suggestions and corrections in the text. Those who have rendered material aid in this line or in other ways not elsewhere mentioned are Dr. John T. Gulick, evolutionist; Dr. N. B. Emerson, ethnologist; Dr. William D. Alexander, historian; Mrs. Emma Metcalf Nakuina, Hawaiian scholar; Mr. Thomas G. Thrum, historian and Hawaiian authority; Dr. Charles H. Hitchcock, geologist; Professor Charles W. Baldwin, geographer; Dr. Henry A. Pilsbry, conchologist; Miss Mary Rathbun, crustaceologist; Dr. Walter K. Fisher, zoölogist; Professor Otto Swezey, Mr. David T. Fullaway, Mr. E. M. Ehrhorn, economic entomologists; Dr. R. C. L. Perkins, Professor Henry W. Henshaw, Mr. Daniel B. Kuhns, naturalists; Mr. J. E. Higgins, horticulturist; Professor F. G. Krauss, agriculturist; Professor Vaughan MacCaughey, Mr. Joseph F. Rock, Mr. Charles N. Forbes, botanists, and to Messrs. D. Thaanum, William Wilder, Irwin Spalding, collectors. The author is under especial obligations to his former student, Mr. D. B. Kuhns, for much help in many fields.

To the author's wife, Elizabeth Letson Bryan, Sc. D., whose interest in his labors has been never failing, a sincere tribute of appreciation is due for constant and valuable help, criticism and suggestions in all departments of the book. Only those who write books can appreciate what her contribution in encouragement, denial, love and service has been to this book.

The half-tone illustrations were made from photographs in the author's collection. They, like the text, have been brought together from many sources. The greater number, however, are from negatives that, at one time or another, have been made expressly for use in this volume. Credit is given for the illustrations in another connection.

Doubtless errors will be found in the text and in the proof-reading by those who search for them. Few will expect absolute perfection. If the bare facts of nature have been clothed with living interest sufficient to make them acceptable and full of information for the general reader, as well as memorable and useful to the student of nature; and if at the same time what has been written falls well within the tenets and tenor of truth as understood by the more critical scientists; and above all, should the book prove generally useful, the author's ambition will have been attained.

WILLIAM ALANSON BRYAN.

The Palms, Honolulu, Hawaii,
September 13th, 1915.

ILLUSTRATIONS.

The illustrations used in the following pages are, in the main, reproduced from unpublished photographs taken by the author, at various times, during a period of many years residence in the islands. In addition to the plates taken especially for this work, a number of choice photographs, many of them of great value, have been secured from various sources, and the author takes this opportunity to publish his indebtedness to his friends and colleagues for generous permission to select and use, from their private collections, such prints as are accredited to them in the following table:

Baker, R. J.—Plate **1**, fig. 2; **23**—4; **25**—2, 3.

Baldwin, C. W. (Author, Geography of the Hawaiian Islands)—Plate **7**, figs. 1, 2, 5, 6; **41**—1, 2, 3, 4; **44**—1, 2, 5, 6, 7; **49**—2, 3; **74**—1, 2, 3, 6, 7, 8.

Bishop Museum, Objects in the (By permission of the Trustees)—Plate **8**, fig. 2; **11**—1, 2, 3, 4; **12**—1; **13**; **77**—4; **78**.

Bonine, R. K.—Plate **90**, figs. 1, 2, 3, 4, 6.

Bryan, W. A.—Plate **8**, figs. 1, 4; **10**—5; **11**—1, 2, 3, 4; **12**—1; **13**—1 to 21; **17**—4; **18**; **19**—1, 3, 4, 5; **20**—1, 2, 4; **22**; **23**—2, 3, 4; **24**; **26**; **29**—1, 3; **30**—1, 2, 4; **32**—1, 2, 3, 4; **33**—1, 2, 3, 4; **34**; **35**—1, 2, 4; **36**—1, 2, 3, 4, 5, 6; **37**—1, 2, 3, 4, 5, 6, 7, 8; **39**; **46**—3; **48**—1, 2, 3, 4; **49**—3; **51**—1 to 18; **52**—1, 2, 3, 5, 6, 8; **53**—1 to 20; **54**—1 to 15; **56**—1 to 14; **57**—1, 2, 3, 6, 7, 9, 10; **58**—1 to 16; **59**—1 to 17; **60**—1, 2, 4, 6; **61**—1 to 17; **62**—1 to 12; **63**—1 to 19; **66**—1, 3, 5, 7; **67**—1, 2, 5, 6, 7; **69**—5; **71**—2; **72**—3, 6; **74**—1; **75**; **77**; **78**—1, 2, 3, 4, 5, 6, 7; **79**—2, 6, 7, 10, 11, 16, 17; **80**; **81**—1 to 9; **82**—1 to 6; **83**—1 to 12; **84**—1 to 6; **85**—1 to 9; **86**—1 to 7; **87**—2, 3, 7; **88**—1 to 16; **90**—1, 2, 3, 4, 5; **91**—1 to 14; **92**—1 to 16; **93**—1 to 11; **94**—1 to 15; **97**—1 to 25; **98**—1 to 19; **99**—1 to 30; **100**; **101**—1 to 27; **103**—1 to 32; **104**—1 to 21; **105**—1 to 27; **106**—1 to 59; **108**—1 to 24; **109**—1, 2, 3, 4, 5; **110**—1 to 29; **111**—1 to 12; **112**—1 to 13; **113**—1 to 16; **114**—1 to 19; **115**; **116**—1 to 24; **117**—1 to 18.

Fisher, W. K.—Plate **79**, figs. 3, 4, 5, 8, 9, 12, 13, 14, 15.

Frear, Hon. W. F.—Plate **21**, figs. 2, 4.

Gartley, A.—Plate **17**, fig. 5; **23**—1; **25**—1; **27**; **35**—3; **64**—1.

Gurrey, A. R., Jr.—Plate **14**; **17**—1; **47**—2.

Henshaw, H. W.—Plate **2**; **3**, figs. 1, 2; **4**—5; **5**; **6**; **8**—5; **12**—2; **15**—1, 2; **16**—2, 5; **31**; **38**; **40**; **42**; **43**; **44**—4; **45**; **46**—1, 2, 4; **47**—4, 5; **48**—5; **49**—1, 5, 6; **50**; **55**; **64**—2, 3; **69**—1, 4, 6, 7; **70**; **71**—1; **72**—1, 5; **73**—6, 7, 8; **74**—1; **87**—4, 5, 8; **89**; **102**—2; **107**.

Lawrence, Miss Mary S. (Author Old Time Hawaiians)—Plate **14**; **17**—1.

MacCaughey, Vaughan—Plate **52**, fig. 7; **57**—4; **60**—3, 7; **66**—4, 6, 9; **67**—3, 4; **68**—3, 5, 9.

Moses, Ernest—Plate **46**, fig. 3; **47**—1.

Perkins, R. W.—Plate **69**, figs. 2, 8.

Pope, W. T.—Plate **33**, fig. 5; **66**—2, 8, 10; **67**—8; **68**—1, 2, 4, 6, 7, 8; **71**—4; **72**—2, 4, 7; **73**—1, 2, 4, 5.

Stokes, J. F. G.—Plate **8**, fig. 2.

Thrum, D. T.—Plate **4**, figs. 1, 2, 3, 4.

Warren, J. T.—Plate **1**, fig. 1; **3**—3, 4; **10**—2, 4, 6; **23**—5; **30**—3; **52**—4; **71**—5; **102**—1.

Williams, J. J.—Plate **9**; **10**, fig. 1; **15**—3, 4; **47**—3; **65**; **76**; **79**—1.

Miscellaneous Sources(Including Hawaii Promotion Committee, Hawaiian Sugar Planters' Exp. Station, College of Hawaii, Purchased Photographs, Etc.—Plate **7**, figs. 3, 4; **8**—3, 6; **10**—3; **16**—1, 3, 4; **17**—2; **18**; **19**—2; **21**—1, 3, 6; **22**; **23**—3; **24**; **26**; **29**—2; **34**; **39**; **48**—6; **57**—5, 8; **60**—5; **65**; **71**—3; **75**; **77**—1, 2, 3, 5; **80**; **82**; **81**; **83**; **84**; **85**; **86**; **87**—1, 6; **88**; **91**; **92**; **93**; **94**; **95**—1, 2, 3; **96**—1, 2, 3, 4, 5, 6.

CONTENTS.

BOOK ONE

SECTION ONE.

THE HAWAIIAN PEOPLE.

CHAPTER I.

COMING OF THE HAWAIIAN RACE.

Plates 1, 2, [3, 5].*

Hawaiians the First Inhabitants—Polynesian Affinities—Evidence of Early Immigration—Traditional and Historical Evidence of Early Voyages—Ancient Voyages—Animals and Plants Brought to Hawaii as Baggage—Double Canoes—Provisions for Long Voyages—Steering a Course by the Stars—Establishment of the Hawaiian Race.

CHAPTER II.

TRANQUIL ENVIRONMENT OF HAWAII AND ITS EFFECT ON THE PEOPLE.

Plates 3, 4, [1, 2, 4, 6, 8, 10, 11, 12, 14, 15, 16, 17, 25, 50, 71, 87, 89, 102, 106].

Natural Environment and its Effect on the People—Kona Weather—Temperature—Effect of the Trade Winds—Altitude and its Effect on Climate—Rains in Hawaii—Effect of a Sufficient Amount of Food—Inter-Island Communication—Inter-tribal War—Agriculture and the Food Supply—The Fauna and Flora Explored by the Hawaiians—Food and its Effect upon the People—Important Foods of the Natives—Response of the Natives to their Environment.

CHAPTER III.

PHYSICAL CHARACTERISTICS OF THE PEOPLE; THEIR LANGUAGE, MANNERS AND CUSTOMS.

Plates 5, 6, [1, 2, 3, 4, 14, 15, 16].

Splendid Stature and Physical Development of the People—Clothing of the People—Cleanliness—Effect of their Life in the Open Air—Their Language—The Alphabet—Genealogy and History—Meles and Hulas—Marriage—Polygamy—Marriage Among Persons of Rank—Infanticide—The Descent of Rank—The Tabu.

CHAPTER IV.

RELIGION OF THE HAWAIIANS: THEIR METHOD OF WARFARE AND FEUDAL ORGANIZATION.

Plates 7, 8, [6, 9, 10, 11, 13, 17].

Religion Among the Hawaiians—Idol Worship—The Future State—Heiaus—Warfare—Temples of Refuge—Preliminary to a Battle—The King and His Power—Sorcerers—The Nobility, Priests and Common People—The King and the Land—Taxes.

* Numerals in brackets indicate plates showing supplementary illustrations.

CHAPTER V.

THE HAWAIIAN HOUSE: ITS FURNISHINGS AND HOUSEHOLD UTENSILS.

Plates 9, 10, [2, 4, 5, 8, 11, 12, 13, 14, 15, 17].

Complete Domestic Establishment—Building of a House—House Furnishings—Household Implements.

CHAPTER VI.

OCCUPATIONS OF THE HAWAIIAN PEOPLE.

Plates 11, 12, 13, [2, 3, 5, 6, 8, 10, 14, 50, 71].

Agriculture Among the Hawaiians—Taro Growing—Agricultural Implements—Irrigation—Planting and Harvesting a Crop—Taro and Its Uses—Poi—Sweet Potatoes and Yams—Breadfruit—Bananas—Fiber Plants, Wauki, etc.—The Manufacture of Tapa—Tapa Making a Fine Art Among Hawaiians—Mat Making—Lauhala Mats—Makoloa Mats—Fishing—Salt Manufacture.

CHAPTER VII.

TOOLS, IMPLEMENTS, ARTS AND AMUSEMENTS OF THE HAWAIIANS.

Plates 14, 15, 16, 17, [3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 28, 35, 87, 89, 106].

The Stone Age—Whet-stones—Rotary Drill—Implements of Stone, Bone and Shell—Ornaments of Feathers—The Kahili—Leis—Medicine Among the Hawaiians—Implements of Warfare—The Hula—Musical Instruments—Boxing the National Game—Wrestling—Spear Throwing—The Primitive Bowling Alley—Summer Tobogganing—Gambling—Cock Fighting—Children's Games—Surf-Riding.

SECTION TWO.

GEOLOGY, GEOGRAPHY AND TOPOGRAPHY OF THE HAWAIIAN ISLANDS.

CHAPTER VIII.

COMING OF PELE AND AN ACCOUNT OF THE LOW ISLANDS OF THE GROUP.

Plates 18, 19, 20, 21, [22, 79].

Pele's Journey to Hawaii—Legend and Science Agree—Geographical Position of the Islands—The Leeward Islands—Ocean Island—Midway—Gambier Shoal—Lisiansky—Laysan—Maro Reef—Dowsett Reef—Frost Shoal—Gardner—French Frigates Shoal—Necker—Nihoa.

CHAPTER IX.

THE INHABITED ISLANDS: A DESCRIPTION OF KAUAI AND NIIHAU.

Plates 22, 23, 24, 25, [75].

Hawaii-nei—Position of the Inhabited Islands—Niihau—Kaula—Lehua—Kauai, the Garden Island—Shore-Line—Waialeale — Lava Soils — Secondary

Volcanic Cones—The Cañons of Kauai—Valleys and Waterfalls—Region of Napali—Barking Sands—Spouting Horn—Caves.

CHAPTER X.

ISLAND OF OAHU.

Plates 26, 27, 28, 29, 30, 31, 32, 33, [22, 71, 73, 75, 87, 106].

Oahu, the Metropolis of the Group—A Laboratory in Vulcanology—Dimensions and Outline of the Island—Honolulu Harbor—Pearl Harbor—Koolau Range — Waianae Range — The Pali — Work of Erosion—Smaller Basaltic Craters and Tufa Cones—Diamond Head—Punchbowl—Elevated Coral Reefs—The Age of Oahu—Black Volcanic Ash—History of Diamond Head—The Geologic History of Oahu—Artesian Wells—Economic Products—Brick—Building Stone—Lime—Points of Geologic Interest About the Island.

CHAPTER XI.

ISLANDS OF MOLOKAI, LANAI, MAUI AND KAHOOLAWE.

Plates 34, 35, 36, 37, 38, [22, 53, 57, 60, 75].

The Position and Relation of Molokai, Maui, Lanai and Kahoolawe—Molokai Described—Valley of Halawa—Mapulehu Valley—The Leper Settlement—Lanai—Kahoolawe—Maui, the Valley Isle—Iao Valley—"The Needle"—Summit of Puu Kukui—Outline of Maui—Haleakala—Plan of East Maui—Trip to the Summit of Haleakala—The Great Crater Described—Sunset Seen from the Summit—Kaupo Gap—Floor of the Crater—History of Haleakala—The Last Eruption.

CHAPTER XII.

ISLAND OF HAWAII.

Plates 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, [17, 22, 27, 50, 52, 55, 72, 74, 75, 87, 89].

Size and Position of Hawaii—The Youngest Island of the Group—The Kohala Range—Waipio and Waimanu Valleys—Hamakua Coast—Summit of Mauna Kea—The Ascent of Mauna Kea—Hualalai—Eruption of 1801—Mauna Loa—Early Exploration of the Mountain—History of the Important Eruptions of Mauna Loa—Earthquake of 1868—Amount of Lava Poured Out in the 1907 Flow—Work of Hawaii's Volcanoes.

CHAPTER XIII.

KILAUEA, THE WORLD'S GREATEST ACTIVE VOLCANO.

Plates 45, 46, 47, [22, 39, 48, 49, 50, 52, 55, 57].

Geologic History of Kilauea—Kilauea an Independent Crater—Dimensions of the Crater—An Exploded Mountain—Rise and Fall of the Liquid Lava—Explosive Eruption of 1789—Condition at the Crater in 1823—Kapiolani Breaks the Spell of Pele—Eruption and Flow of 1840—Eruption of 1892-94—Ac-

tivity in 1902—Activity in 1907—Account of a Visit to Kilauea in 1909—The Journey—First Glimpse of the Crater—Steam Cracks—Sulphur Beds—Kilauea-iki — Keanakakoi — Descent Into the Great Crater — Heat Cracks — Spatter Cones—The Pit of Halemaumau by Day and Night—Side Trips from the Crater—Fossil Tree Moulds—The Road to Honuapo—Kona District.

CHAPTER XIV.

CONDENSED HISTORY OF KILAUEA'S ACTIVITY.

Plates 45, 46, 47, 48, 49, [See Chapter XIII.]

Brief Chronology and History of Kilauea from the Earliest Records of Its Eruptions Down to the Present, with Dates and Observations on the Condition of the Lava in the Crater of Kilauea and the Pit of Halemaumau.

SECTION THREE.

FLORA OF THE GROUP.

CHAPTER XV.

PLANT LIFE OF THE SEA-SHORE AND LOWLANDS.

Plates 50, 51, 52, 53, 54, 55, 56, 57, [5, 14, 19, 30, 33, 40, 43, 60, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 76, 78, 79].

The Island Flora—Its Isolation and Peculiarities—Sources—Number of Genera and Species—Endemic and Introduced Plants—Variation in Flora from Island to Island—Floral Zones—The Lowland Zone—Common Littoral Species—Common Plants from the Sea-Shore to the Lower Edge of the Forest—Introduced Plants—Grasses.

CHAPTER XVI.

PLANT LIFE IN THE HIGH MOUNTAINS.

Plates 58, 59, 60, 61, 62, 63, [23, 25, 44, 45, 46, 50, 52, 55, 56, 57, 74].

Plants of the Lower Forest Zone—Fiber Plants Cultivated by the Hawaiians—Sandalwood—Middle Forest Zone—Giant Ferns—Upper Forest Zone—Silver-Sword—Mountain Bog Flora.

SECTION FOUR.

AGRICULTURE AND HORTICULTURE IN HAWAII.

The Introduced Plants and Animals of Forest, Field and Garden.

CHAPTER XVII.

A RAMBLE IN A HONOLULU GARDEN: PART ONE.

Plates 64, 65, 66, [2, 4, 5, 41, 45, 53, 67, 68, 69, 70, 71, 72, 73, 74, 90].

First Impressions of Honolulu—Palms—A Falling Leaf—Cocoanut Palm—

Date Palm—Ornamental Palms—Araucaria — Kukui — Breadfruit — Mango—Monkey-Pod—Algaroba.

CHAPTER XVIII.

A Ramble in a Honolulu Garden: Part Two.

Plates 67, 68, [See Chapter XVII].

Ornamental Trees—Poinciana—Pride of the Barbadoes—Golden Shower—Pride of India—Tamarind—Banian—Pepper Tree—Kamani—Black Wattle—Australian Oak—Bougainvillea—Allamanda—Bignonia—Vines and Shrubs—Hedge Plants—Crotons—Ki—Pandanus—Ferns—Night-Blooming Cereus.

CHAPTER XIX.

Tropical Fruits in Hawaii.

Plates 69, 70, [5, 50].

Native and Introduced Fruits—Strawberry—Raspberry—Ohelo—Mountain Apples—Poha—Bananas — Pineapples — Alligator Pears — Papaia — Guava — Lemons, Oranges, Limes, Etc.—Wi—Cusard Apples—Sour Sop—Cherimoya—Sapodilla—Loquat—Figs—Grapes—Mulberry—Eugenia—Rose Apple—Passion Fowers—Pomegranates—Lichi—Melons—Prickly Pear.

CHAPTER XX.

Agriculture in Hawaii: Its Effect on Plant and Animal Life.

Plates 71, 72, 73, 74, [2, 25, 41, 53, 95, 96, 97, 98, 99].

Agriculture in Recent Times—Sugar—Rice—Coffee—Sisal—Fiber Plants—Cotton—Rubber—Tobacco—Potatoes—Sweet Potatoes — Cassava—Castor Bean Plant—Lotus—Peanuts—Sorghum—Forage Grasses—Weeds—Live Stock.

BOOK TWO

SECTION FIVE.

THE ANIMAL LIFE OF THE GROUP.

CHAPTER XXI.

Various Animals from Land and Sea.

Plates 75, 76, 77, [21, 74].

Hawaiian Rats—Plague Carriers—Royal Sport—Mice—Rabbits—Guinea Pigs—Cats—Bats—Hogs—Dogs— Chickens— Goats—Deer— Mongoose— Skinks and Geckos—Frogs and Toads—Snakes—Sea Turtles—Galapagos Land Tortoise —Porpoise—Dolphin—Whales—Whaling Industry.

CHAPTER XXII.

Introduced Birds.

English Sparrows—Rice Birds—Chinese Sparrows—Chinese Turtle Doves—Mynahs—The Skylark—Pheasants—California Partridge—Chinese Thrush.

CHAPTER XXIII.

BIRDS OF THE SEA.

Plates 78, 79, [19, 20, 21, 76, 80, 81].

Regular Visitors and Ocean Waifs—Tropic Birds—Petrels—Shearwaters—Terns—Albatross—Man-o'-War Bird—Birds of Laysan Island—Miller Bird—Laysan Canary—Laysan Honey-eater—Hawaiian Rail—The Albatross Dance—Guano Deposits—Nesting Habits of the Man-o'-war Bird—White Terns—Grey-backed Terns—Laysan Duck—Flightless Rail—Land Birds of Laysan.

CHAPTER XXIV.

BIRDS OF THE MARSH, STREAM AND SHORE.

Plates 80, 81, [78, 79].

The Golden Plover—Old 'Stump-leg'—Turnstone—Sanderling—Tattler—Curlew—Hawaiian Stilt—Black-crowned Night-Heron—Coot — Gallinule—The Legend of Maui and the Alae—Hawaiian Duck—Foreign Ducks.

CHAPTER XXV.

BIRDS OF THE MOUNTAIN FORESTS.

Plates 82, 83, 84, 85, [80, 81].

Fifty-six Species — Elepaio — Apapane — Iiwi — Amakihi — Oreomystis — Thrush-like Birds—Finch-like Birds—Moho—Black Mamo — Oo — Hawaiian Duck—Hawaiian Goose—Crow—Viridonia—Hoi—Hawaiian Hawk—Hawaiian Owl—Family Drepanididæ—Extinction of Hawaiian Birds.

CHAPTER XXVI.

HAWAIIAN FISHES: PART ONE.

Plates 86, 87, [9, 13, 16, 88, 89, 90, 91, 92, 93, 94, 102, 106].

Fishing in Former Times—Fishing Outfits—Fish Poison—Fish Bait—Shark Fishing — Man-Eater Sharks — Hammer-Head Sharks — Dogfish — Mackerel-Sharks—Killers—Rays and Skates—Sting-Ray—Sea Devil.

CHAPTER XXVII.

HAWAIIAN FISHES: PART TWO.

Plates 88, 89, 90, [See Chapter XXVI].

Food Fish in the Market—Anchovies—Barracudas—Butterfly-Fish—Blennies—Bone-Fish—Catalufas—Cirrhitidæ—Dophin—Eels — Frog-Fish— Flying-Fish—Gobies—Flying-Gunards—Headfish—Mullet—Awa.

CHAPTER XXVIII.

HAWAIIAN FISHES: PART THREE.

Plates 91, 92, 93, 94, [See Chapter XXVI].

Flatfish — Morays — Mackerel — Milk-Fish — Needle-Fish — Pampanos — Tarpon—Parrot-Fish—Pipe-Fish—Porcupine-Fish—Porgies—Puffers—Remoras

or Sucker-Fish—Scorpion-Fish — Sea-Bass — Snappers — Soles — Flounders — Squirrel-Fish—Surgeon-Fish—Surmullets or Goat-Fish — Swordfish — Trigger-Fish—Trunk-Fish—Trumpet-Fish.

CHAPTER XXIX.

INTRODUCED FRESH WATER FISH.

Goldfish—Carp—Catfish—China Fish—Black Bass—Trout—Salmon—Top Minnows or Mosquito Fish.

CHAPTER XXX.

IMPORTANT ECONOMIC INSECTS: PART ONE.

Plates 95, 96, [97, 98, 99].

The Study of Insects—Destructive Species—Control by Natural Enemies—Sugar-Cane Leaf-Hopper—Sugar-Cane Borer—Lantana Insects—Maui Blight—Mediterranean Fruit-Fly—Melon-Fly—Horn-Fly—Flies — Mosquitoes — Sugar-Cane Insects—Aphids or Plant-Lice.

CHAPTER XXXI.

IMPORTANT ECONOMIC INSECTS: PART TWO.

Plates 97, 98, 99 [95, 96].

Scale Insects—Ladybird Beetles—Beetles—Japanese Beetles—Fuller Rose Beetle or Olinda Beetle—Weevils—Leaf-Rolling Moths—Cutworms—Army-Worms—Hau Moth—Loopers—Silkworms—Cabbage Butterfly—Sweet Potato Horn-Worm or Humming-Bird Moth—Cotton Boll-Worm—Bird-Lice—Lice—Mites—Ticks—Fleas—Bubonic or Black Plague carried by Fleas—Cockroaches—Bedbugs—Bugs—White Ants—Silverfish — Ants — Carpenter Bees — Mud-Daubers—Wasps—Honey-Bee — Clothes-Moth — Household Pests — Centipedes—Scorpions—Thousand-Legged Worms—Sow-Bugs or Slaters—Sand-Hoppers—Spiders, Mites and Ticks—House-Spider—Jumping-Spiders—Hamakua Spiders.

CHAPTER XXXII.

NATIVE INSECTS.

Character of the Native Fauna—Insects Occurring on Mamaki—Ants, Bees and Wasps — Beetles — Fleas — Two-Winged Insects or Flies and Mosquitoes—Butterflies and Moths—Dragon-Flies and the Nerve-Winged Insects—The True Bugs—Plant-Lice—Jumping Lice—Leaf-Hoppers, etc.—Thrips—Grasshoppers, Crickets, Cockroaches, Earwigs—Wingless Bird-Lice—Silverfish—Spring-Tails.

CHAPTER XXXIII.

LAND AND FRESH WATER SHELLS.

Plates 100, 101 [75, 103].

Character of the Fauna—Land Shells—Variations—Difficulties of Classifica-

tion—Color Varieties—Important Families Represented—Common Forms Described—Earthworms.

CHAPTER XXXIV.

SHELLS FROM THE SEA-SHORE: PART ONE.

Plates 102, 103 [104, 105, 106].

Pleasure of Collecting Shells—The Common Forms Numerous—Three Types of Mollusca—Mussels, Clams, Scallops, Oysters—Attempts at Oyster Culture—Gasteropods, including the Snails, Slugs, Whelks, Cowries, Periwinkles, etc.—Spiny Rock Shells—Tritons—Spindle Shells—Whelks—Dog Whelk—Mitre Shells—Margin Shells—Olives—Harp Shells—Dove Shells—Grey Shells.

CHAPTER XXXV.

SHELLS FROM THE SEA-SHORE: PART TWO.

Plates 104, 105, [See Chapter XXXIV].

Cone Shells—Auger Shells—Conch Shells—Cowry Shells—Egg Shells—Tun Shells—Cameo Shells—Moon Shells—Slipper Shells—Limpets, etc.—Worm Shells—Cæcum Shells—Eulimas—Pyramid Shells — Sun-Dial Shells — Violet Snails—Ladder Shells—Cerithiidæ—Periwinkles—Sea Snails—Turban Shells—Top Shells—Keyhole Limpets—Umbrella Shells—Chitons—Bubble Shells—Sea Slugs.

CHAPTER XXXVI.

PLANTS AND ANIMALS FROM THE CORAL REEF: PART ONE.

Plates 106, 107, 108, 109, 110, [72, 102, 103, 104, 105, 111, 112, 113, 114, 115, 116, 117].

The Common Crabs—The Lobster—Prawns—Shrimps—Hermit Crabs—Barnacles—Common Corals—Sea-Anemonies—Coral Reefs—Eight-Rayed Corals—Sea-Fans—Sea-Plumes, etc.—Jellyfish—Hydroids — Portuguese Man-of-war—Sea Money—Moss-Animals—Lamp Shells—Sea-Squirts—Balanoglossus.

CHAPTER XXXVII.

PLANTS AND ANIMALS FROM THE CORAL REEF: PART TWO.

Plates 111, 112, 113, 114, 115, 116, 117, [See Chapter XXXVI].

Starfish — Sea-Urchins — Brittle-Stars — Sea-Cucumbers — Sea-Lilies or Crinoides — Flat-Worms — Bristle-Worms — Earthworms — Single-Celled and Many-Celled Animals—Sponges — Protozoa — Seaweeds — How to Collect Hawaiian Algæ.

PLATE 1. TYPICAL OLD HAWAIIANS OF TODAY.

(For Description of Plate See Opposite Page.)

Natural History of Hawaii.

SECTION ONE

THE HAWAIIAN PEOPLE.

CHAPTER I.

THE COMING OF THE HAWAIIAN RACE.

Hawaiians the First Inhabitants.

The Polynesian ancestors of the Hawaiian race are believed to be the first human inhabitants to set foot on Hawaii's island shores. Inasmuch as the group comprises the most highly isolated island territory on the globe, it seems logical to infer that this sturdy race must have migrated to Hawaii from other lands. By tracing the relationship of the original inhabitants it has been found that they belong to the same race as the natives of New Zealand, Samoa, Marquesas, Society, Tonga and other islands in the southern, central and eastern Pacific.

That all the native people found over this vast Pacific region are the scattered branches of one great race, springing from a common ancestral stock, has been demonstrated in many ways. The marked similarity in the manners and customs, language and religion, as well as many peculiar physical characteristics and intellectual traits common to the inhabitants of the widely scattered Pacific islands just mentioned, leaves little doubt in the minds of those who have studied these people of the Pacific, as to their racial affinities.

Polynesian Affinities.

Collectively, this group of Pacific Islanders has been called by Europeans the Polynesian race, a reference to the many islands inhabited by them. The exceedingly vexed question as to the genesis of the race as a whole and the fixing of the place from whence the progenitors of the dark-skinned kanaka people entered the Pacific has long been a subject of interesting discussion.

Since the genesis of the race is by no means a settled question it will not be profitable in this connection to dwell upon the matter farther than to say

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Description of Plate.

The splendid physique of the people, their well shaped heads, attractive features and kindly eyes are well shown by the photographs and indicate the strong individuality and lovable character of the race as a whole. Old Hawaiians, especially of the better class, possessed a high type of Polynesian culture that embraced a thorough and useful knowledge of their isolated environment. At the time of their introduction to European civilization many among them were intimately acquainted with their own history and genealogy, as well as with the fund of information concerning their traditions, myths, arts, occupations and practices; moreover they possessed a store of knowledge about the islands and their natural history that at once won for the race the respect and admiration of their European benefactors.

that the origin of the Polynesian race has been traced by different writers, in different ways to various places. North, South and Middle America, as well as Papua, Malay, China, Japan and India, have each in turn been declared the cradle of this widely distributed people and each made responsible, directly or indirectly, for their presence in the Pacific Ocean.

While it is probable that the origin of the race, as a whole, will always be shrouded in doubt, there is little uncertainty as to the more immediate ancestors of the Hawaiian people. All their various affinities seem to point unerringly in the direction of the islands to the south of us. Although the Society and Samoan Islands, which are the nearest islands in any direction at present inhabited by this race, are more than two thousand miles distant, they, without doubt, form the stepping stones over which the early immigrants passed—if they are not the actual points of origin of the migrations that resulted in the settling of the Polynesian race on this, the most remote group.

Evidence of Early Immigrations.

That the race existed here ages ago, perhaps far beyond the traditions of the people, is believed by some to be proven by certain geologic evidence. Whatever the geological facts may be, and the data thus far secured is by no means conclusive, the traditions of the people are more certain. They throw much light on the antiquity of the early voyages of the race and point far back into the shadowy past. Their genealogies, which were handed down from father to son with remarkable accuracy, also contribute much information that can be accepted as reasonably authentic and historic, and give a fair basis for measuring time, especially during the past four or five centuries. The comparative study of genealogical records has brought to light proof of many obscure points that had to do with the history and wanderings of the race as a whole, but their traditions are especially clear with reference to the Hawaiians themselves.

Traditional and Historical Evidence of Early Voyages.

Those who have studied the history and traditions of the Polynesians as a people regard Savaii, in the Samoan group, as the most likely center of dispersal. It is probable that at least one of the bands of early voyagers that settled on these, then presumably unpeopled islands, came from that group in very ancient times,—perhaps as long ago as 500 B. C. Just why these early wanderers set out on the long perilous journey over unknown seas will never be known. It is suggested that they may have been forced from their early homes by war and driven from their course by storms. But since there was no written language, the historian, as already stated, is forced to rely for his data on legends, traditions, genealogies and such other meager scraps of information as are available.

Unfortunately, of the very early period scarcely a reliable tradition exists. We are therefore left free, within a certain measure, to construct for ourselves such tales of adventure, privation and hardship as seem sufficient to account for the appearance of the natives in this far-away and isolated land. We know

that the first voyages, like many undertaken in more recent times, must have been made in open boats over an unfriendly and uncharted ocean. We know also that they survived the journey and found the land habitable when they came.

To the dim and uncertain period covering the several centuries that followed, many great primitive achievements have been ascribed. Among them are such tasks as the building of walled fish-ponds, the construction of certain great crude temples, the making of irrigation ditches, and the development of a distinct dialect, based of course, on their ancient mother tongue. But at last, after the lapse of centuries, perhaps many centuries, this long period of isolation and seclusion ended and communication was once more resumed with the rest of the Polynesian world.

Ancient Voyages.

It is reliably recorded in the traditions of the race, but more especially in those of the Hawaiian people, that after many generations of separation from the outside world, communication was again taken up and many voyages were made to Kahiki—the far-away land to the south. From this time on the story of the people becomes much more definite and reliable. We not only know that intercourse was resumed between Hawaii and the islands of the South Pacific, but the names of several of the navigators and the circumstances, as well as the time when their journeys were made, also incidents of their voyages, have come down to us. In some cases the same mariner is known to have made more than a single journey. Naturally the exploits of the brave navigators of the race were made matters of record in the minds of the people and handed down from father to son in numberless songs, stories and traditions. As a matter of fact, there is evidence to prove that during the twelfth and thirteenth centuries of our Christian calendar there came an era of great unrest throughout the whole of Polynesia and a great number of voyages were made to the remote parts of the region. In fact it is asserted in the tradition of the people that "they visited every place on earth." This broad statement seems to indicate that to the Polynesian mind the world was confined to Oceanica, as they appear to have known nothing of the great continents which surrounded them on every side. At any rate, there is on record a considerable list of these voyages and an equally long list of the places where they landed, accompanied by incidents of their wanderings.

Animals and Plants Brought to Hawaii as Baggage.

Our special interest in the natural history of the plants and animals of Hawaii makes this period of Pacific travel of unusual importance. It was at this time that most, if not all, of the useful plants and animals that had followed the race in their various wanderings were brought as precious baggage with them to these islands from over the sea.

Any one who has experienced the difficulties and disappointments encountered in transplanting a young breadfruit tree from one valley to another, will

PLATE 2. HAWAIIAN GRASS HOUSE WITH TYPICAL SETTING.

The house shown is in a valley near the stream and is surrounded by a few useful trees and plants including the cocoanut, mountain apple, banana and taro. The small terraced taro ponds nearby are supplied with water drawn by ditches from the swift rocky stream. In the extreme distance the valley is crossed by a trestle carrying a modern irrigation flume.

appreciate in a measure the difficulties that must have beset the Hawaiians in transporting living cuttings of this delicate seedless plant from far off Kahiki to these islands, yet it is practically certain that not only was the breadfruit brought here in this manner but also the banana, the taro, the mountain apple, the sugar-cane and a score or more of their other important economic plants. The wild fowl, the pig and the dog were also brought with them in the same way, in very early times, and were in a state of common domestication over the group when the islands were first visited by the white race.

Naturally there were many references in Hawaiian and Polynesian tradition to these long and tempestous voyages. When all the circumstances surrounding these rugged feats of daring and adventure are considered, it is not too much to say that the race to which the ancient Hawaiians belonged is worthy of a special place among the most daring and skillful navigators of all times. To this day their prowess and aptitude in matters pertaining to the sea is such as to command the admiration and respect of all.

Double Canoes.

The making of the large canoes employed in their important journeys by the use of stone tools alone, was by no means an ordinary task. Aside from the descriptions of their canoes handed down to us in their traditions, we know that a century ago there existed in these islands the remains of war canoes, such as we are told were used in those early voyages, that were seventy feet in length by more than three feet in width and depth, capable of carrying seventy persons from island to island. What is still more remarkable the hull in each case was carved from a single giant koa log.

The selecting of a suitable tree from among its fellows in the mountain forests, the felling and shaping of it by means of the crude stone implements of the time, and the subsequent transporting of the rough-hewn canoe to the sea by main strength, was an undertaking not to be lightly assayed; but the executing of a 2000-mile voyage in such a craft seems almost incredible. In this connection it is well to remember that the early Polynesians made not only single canoes of monstrous proportions, but double ones by lashing two together and rudely decking over the space between them. In this ingenious way they made a craft capable of carrying a large number of people and a goodly supply of provisions.

Provisions for Long Voyages.

It is probable that in their more extended voyages, especially when they were voluntarily undertaken, the natives used the double canoe and provided the craft with a mast to which they rigged large, durable sails made of mats. The legendary mele telling of the coming of Hawaii-loa states that during five changes of the moon he sailed in such a craft to be rewarded at last by the sight of a new land ever after called Hawaii.

As to the supply of provisions it is to be remembered that the Polynesians

have several kinds of food capable of being preserved in a compact form. The cocoanut, either fresh or dried, was an invaluable article of food, while dried fish and squid are not to be despised. The taro, breadfruit and sweet potato, or yam, are articles of daily diet, capable of being transported in an edible condition for great distances at sea. Besides cocoanut water, in the nut, to drink, they had utensils for storing fresh water and it is probable that they provided themselves with calabashes and wooden bowls specially prepared for use on their long sea journeys.

Steering a Course by the Stars.

As they were expert fishermen and exceedingly hardy seamen the perils of the deep were considerably minimized. Add to this their intimate knowledge of the food to be found living everywhere in the sea at all seasons and their acquaintance with the habits and methods of capture, as well as skill in the preparation of such animals and plants as they esteemed as food, and we must conclude that they were by nature well fitted for such journeys. With such substitute food as the sea would furnish, always at hand, it was possible for them to travel far and suffer but little, for they were able to eat, not only such fresh and dried food as we have mentioned, but to relish many creatures of the sea in a raw state—as flying-fish, squid and seaweed—that would scarcely be thought of as food by a more fastidious people. Moreover, in making these journeys they were able to roughly guide their course by the stars, the sun and the moon, as they had a crude but working knowledge of astronomy. In addition to this they had a number of traditions, telling of mysterious lands, far away beyond the horizon, that served them both as an inspiration and an assurance, besides being useful to them in many ways in their practical navigation.

Establishment of the Hawaiian Race.

Great care was always exercised in selecting the proper place and season for setting forth on their journeys. Once having made a successful voyage they were particular to start from the same spot in making similar journeys thereafter. In this way the south point of Hawaii as well as the southern end of the little island of Kahoolawi came to be known as the proper points from which to embark on a journey to Tahiti.

There is but little doubt that in those times they were expert navigators, who in addition to being able to guide their courses at sea by the stars, also knew the art of steering their canoes in such a fashion as to catch and ride great distances on the splendid long ocean swells, after the manner of the surf riders of less adventurous times.

Just how these striking feats of navigation were accomplished we may never know. At any rate there is every reason to believe that they were performed. We do know, however, that the perils attending them were safely passed, the difficulties of the journeys surmounted, and that those who performed them lived to tell the tale of their daring to their children, and they to

their children's children. We know that through them in time the Polynesian race came to occupy a new land, established the Hawaiian people and built up a crude though worthy civilization.

CHAPTER II.

TRANQUIL ENVIRONMENT OF HAWAII AND ITS EFFECT ON THE PEOPLE.

The Natural Environment.

Without dwelling further on the remote and uncertain period which had to do with the origin and early migration of the Hawaiian people, it will be fitting to briefly consider the race in connection with their natural environment. It is well within the purpose of this sketch of the natural history of Hawaii to treat of the people as the native inhabitants, and for that reason we shall dwell upon their primitive and interesting native culture rather than their more recent political history.

In dealing with the race as a natural people it will be of interest to enumerate some of the various forces of nature among which they developed for centuries, since without doubt their environment helped to make the race what it was at the time of its discovery,—a swarthy, care-free, fun-loving, superstitious people, with a culture that, now it has been more fully studied by unbiased ethnologists and is better understood, has at last gained for the ancient Hawaiians, not only the respect, but the admiration of their more highly cultured and fairer skinned brothers. In seeking only to depict their life as it was in the interesting time of their primitive paganism, before Christianity was brought to them, we must leave entirely out of account the story of one of the most remarkable religious and political developments that a race has ever under-gone in the history of the civilized world.

So capable and receptive was the Hawaiian race that within less than an hundred years the entire population has not only embraced a foreign and exceedingly advanced form of religion, but by its agency transformed their language, practices, customs, manners, arts and morals to such a degree that today hardly a trace of their former culture remains to indicate the long road which they have traveled in the upward march from a rude rule of might, fear and superstition to the place where their representatives, chosen by ballot, sit on equal terms in legislative assemblages with their one-time patrons and would-be benefactors, and, without fear or favor, creditably discharge the duties of citizenship in the great American Republic.

Kona Weather and Trade Winds.

One of the most important physical influences that has affected the people is the climate. Although the Hawaiian Islands lie at the northern edge of the torrid zone, their climate is semi-tropical rather than tropical, and is several

PLATE 3. HAWAIIAN CHILDREN.

1. Hawaiian boy with wavy hair. 2. Hawaiian girl with straight hair. The holoku or dress is of a style introduced by the early missionaries; the lei or necklace of flowers is of introduced red and white carnations. 3, 4. Typical children of the country villages; their faces are to be contrasted with the serious, dreamy expressions of figs. 1 and 2.

degrees cooler than that of any other country in the same latitude. The temperature is moderate, at least ten degrees below the normal, owing to the influence of the cool northeast ocean currents. The delightfully cool northeast trade wind, which is obviously the principal element in the Hawaiian climate, blows steadily during at least nine months of the year. During the remaining months the wind is variable, and occasionally storms with heavy rains blow from the southwest, producing what is known as "Kona"[1] weather. Taken through a long period, the temperature at sea level rarely rises above 90 degrees during the hottest day of the year, and seldom falls below 60 degrees for more than a few hours at a time, with the mean temperature fluctuating about 75 degrees Fahrenheit. The difference between the daily average midsummer and midwinter temperature is about 10 degrees. With reference to human comfort the temperature excells for its equableness. This fact, coupled with the refreshing trade winds that sweep over thousands of miles of cool ocean and the bright and genial warmth of the tropical sun, produces the climate of Paradise—a condition found in no other region on the globe.

Altitude and Its Effect on Climate.

In fact the Hawaiian language had no word for "weather," as it is usually understood. Nevertheless, a remarkable difference in climate is experienced in passing from one side of the islands to the other, or from lower to higher altitudes. The northeast, or windward side of the group, which is exposed to the trade winds, is cool and rainy, while the southwestern or leeward side is, as a rule, much drier and warmer. The most important variation, however, is due to altitude; the thermometer falling about four degrees for every 1,000 feet of ascent. It is therefore possible to look from the palm groves that bask in tropical warmth along the coast of Hawaii to the highest mountain peak of the group,[2] to find it frequently snow-capped, particularly during the cooler months. As to rainfall, similar variations occur. At Honolulu the average precipitation is thirty-eight inches, at the Pali, five miles away in the mountains, 110 inches; while at Hilo, on the north side of Hawaii, it is nearly twelve feet. If the group is taken as a whole, almost every variation from warm to cold, wet to dry, windy to calm, may be found.

Effect of a Sufficient Amount of Food.

The direct influence of these facts on the character of the people, however, is rather obscure. Aside from the bearing it may have had on their clothing, food and shelter it is indeed difficult to trace. Although it is the general opinion that a warm climate is not liable to be conducive to a higher culture, there is plenty of evidence to the contrary here and elsewhere, and, considering the insular position of the Islands, their limited food supply, the lack of raw materials for manufacture, the absence of such metals as iron and copper and

[1] Southerly. [2] Mauna Kea, 13,825 feet

the want of domestic animals as beasts of burden, the Hawaiians achieved a remarkably high stage of development before their discovery. The degree of their development is especially shown, as we shall see, by the thoroughness with which they had explored their environment and utilized the natural raw materials which it supplied.

The easy tropical conditions, as well as the unsettled political state which surrounded them originally, were not necessarily conducive to the highest physical or mental achievements. According to Blackman, the regular recurrence of a sufficient amount of food to supply their needs may also have prevented the development of the traits of thrift and frugality that are so inbred in the races of the north. There is no doubt that the bright, warm, cheerful climate had its influence on their temperatment, their health, and their home life, by diminishing the relative importance of permanent shelter, by enticing the people out of doors; and also on their morality, as we interpret it, by rendering clothing the thing least required for bodily comfort.

Inter-Island Communication.

Another important point in their environment was the fact that the inhabited islands were sufficiently numerous and near enough together to influence one another decisively, yet far enough apart to make inter-island communication difficult. The group was far enough removed from other groups to prevent frequent migrations and small enough to render a wandering life and contact with other people and tribes impossible. At the same time they were just far enough away from each other to satisfy the natural human desire for travel, adventure and experience.

Inter-Tribal Wars.

The valleys on the various islands constituted natural divisions of the land that had a marked influence on the government of the people by district chiefs who were frequently at war with one another. To offset this there were inter-tribal and inter-island marriages enough to produce a uniform stock throughout the group. This interchange of blood and ideas was most beneficial in bringing about the homogeneity and compactness necessary to preserve inherited habit and secure the persistence of traditions, customs and the learning of the whole people.

Agriculture and the Food Supply.

Although the valleys are usually fertile, they are limited in extent. The soil though rich, varies greatly in productiveness, and being of a porous nature, needs much water to render it valuable for the various pursuits of agriculture. To meet this demand, extensive irrigation systems were built and used by the native farmers. Besides the valley lands, there are broad tracts of rough lava and dry upland country that were of little use to the aborigines with their primitive methods of agriculture. In brief, the conditions were such as to require much labor and skill to produce sufficient food from the soil to supply

their wants. For this reason, among others, their life was not the one of indolence it is sometimes thought to have been, yet conditions were uniformly more favorable to life in Hawaii than were those met with in certain other groups in the Pacific to which Polynesians migrated and settled, presumably as they did in these islands.

Fauna and Flora Explored by the Hawaiians.

So much must be said of the animals and plants in another connection that, though they form an important feature of environment, it will suffice here to note the salient facts. The flora furnished trees for the construction of their canoes and houses, the implements of their warfare and peaceful pursuits, the raw material for the manufacture of their clothing, nets, calabashes, medicines, and above all, a sufficient amount of wholesome food throughout the year to provide for their sustenance.

The most important animals existing on the islands at the time of their discovery by the whites were the swine and the dogs, both of which were freely used as food. There were domestic fowls of the same species as were common throughout the Polynesian islands. The waters about the group provided a never failing supply of fish food. The insects were all inconspicuous and harmless. The only game birds, as ducks and plovers, were not abundant, while the reptiles were represented by a few species of small, inoffensive lizards that were of little importance.

The Hawaiians were preëminently an agricultural people with a natural love for the soil and its cultivation. They had an appreciation of the beautiful in flower and foliage that has had an abiding influence on their homes and home surroundings. They were also skilled fishermen. The lack of animals, domestic or wild, other than the few species mentioned, prevented them from following the hunting and pastoral life, and as a result they were settled in permanent villages, usually along the coast.

Since there were no noxious insects, poisonous serpents or dangerous birds or beasts of prey, there was no occasion for the alertness and constant fear that so frequently makes life in a tropical country a never-ending strain if not an actual burden.

Food and Its Effect on the People.

While the chiefs and the more prosperous of the people were well supplied with meat, the common people had it only at rare intervals. They were forced to subsist on a diet chiefly vegetable, which was lacking in variety, and, although fat-producing, was also diffuse and bulky. To the character of their food may be attributed the habit of alternately gorging and fasting, which was so common a trait of the ancient Hawaiians, and which is believed to have resulted in the abnormal development of the abdomen, formally so noticeable among them.

Although taro was the staff of life in Hawaii, sweet potato, or yam, also figured largely in the every day diet of the common people. Though meat was never abundant, as has been stated, they were not entirely without ani-

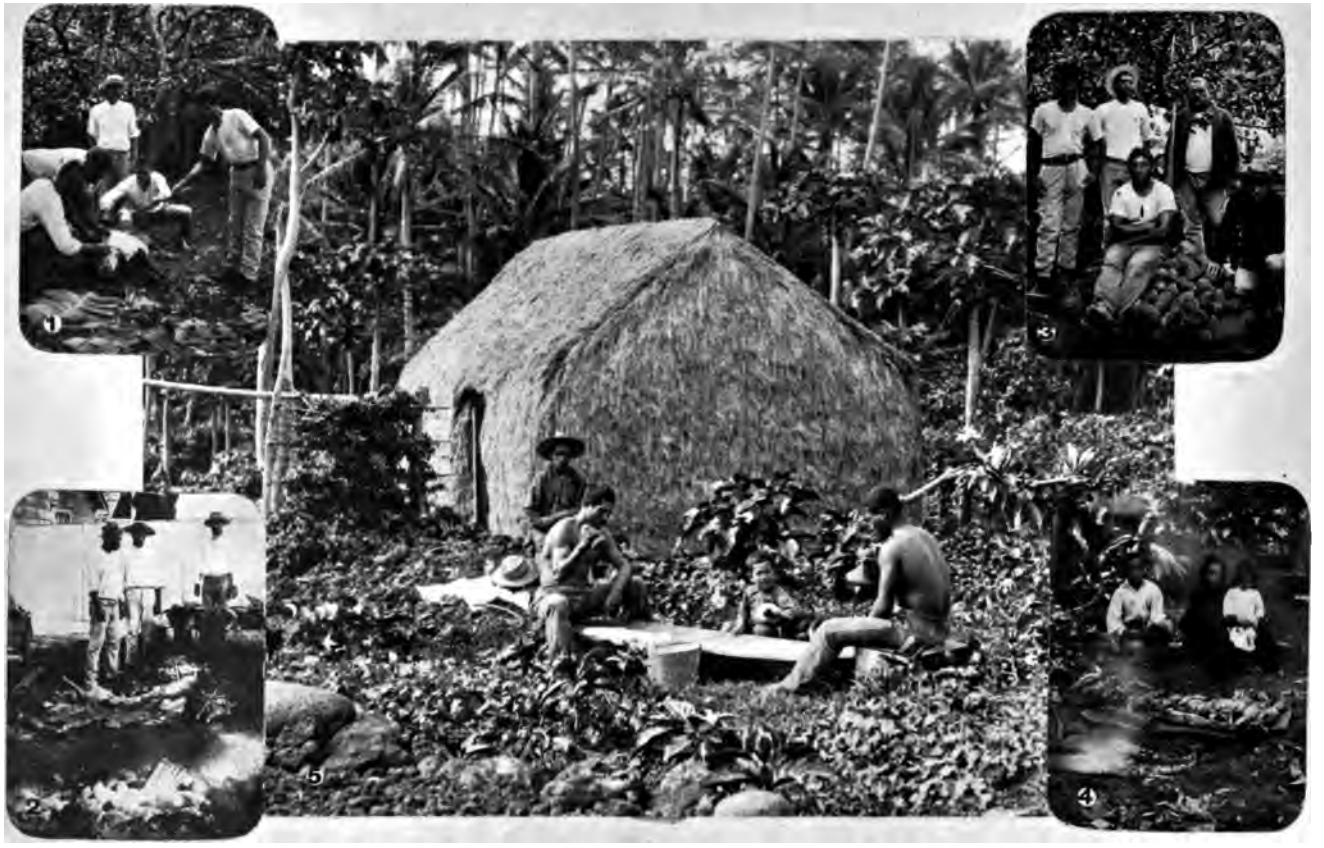

PLATE 4. PREPARING HAWAIIAN FOOD.

(For Description of Plate See Opposite Page.)

mal food. Fish was always available and fairly plentiful, and certain kinds were often eaten raw. Fowl, pork and dogs were occasionally to be had as a change and were much esteemed as delicacies. The poi-dog, when carefully fed and fattened on poi, was regarded as even more delicious in flavor than pork. Dogs always formed an important dish at the native feasts and on such occasions large numbers of them would be baked in earth ovens.

Response of the Natives to their Environment.

Looking broadly at their environment it may be said that the most decisive factors in the surroundings of the Hawaiian race were isolation, the evenness of the climate and the conditions which made the pursuit of agriculture a necessity. The latter induced a more regular and constant activity and more settled life than is found among a hunting and roving people, and in connection with the other conditions mentioned it had an important bearing on the temperament of the race. The isolation, even temperature, and always sufficient food supply must have had their effect in producing a patient, tranquil, self-reliant mind—a satisfied disposition—an even temper—a settled attachment to the soil—an aptitude and faculty for the development of their peculiar forms of learning, and above all, habits of life and customs of dress that were peculiarly suited to and the result of the gentle demands of their environment.

CHAPTER III.

PHYSICAL CHARACTERISTICS OF THE PEOPLE.

Stature and Physical Development of the People.

At the time of the discovery of the Hawaiians they were physically one of the most striking native races in the world. Moreover, they were distinguished as being among the kindest and most gentle mannered of people, and but for the oppression of their priests and chiefs, they would undoubtedly have been among the happiest.

As a race they were tall, shapely and muscular, with good features and kind eyes. In symmetry of form the women have scarcely been surpassed, if equalled, while the men excelled in muscular strength, particularly in the region of the back and arms.

The average height of an adult Polynesian is given as five feet nine and a third inches, and the Hawaiians were well up to, if not above, that average, while individuals of unusual size, often little short of giants, were not uncommon

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Description of Plate.

1. Scraping and preparing a pig [puaa] for baking. 2. The earth oven [imu] hollowed out and filled with heated stones ready for the food. 3. The imu filled and closed; the heat and steam bakes the food which is wrapped in ki or banana leaves. 4. The food baked and ready to be eaten. 5. Pounding poi on a "double" board [papa kui poi], which is a shallow trough made of hard wood; "single" boards were also common. About the grass house may be seen cocoanut palm trees in the rear, papaya trees to the right and left and a small noni tree at the end of the house.

among them. There is an authentic record of a skeleton found in a burial cave that measured six feet seven and three-quarters inches in length, and there is sufficient evidence to establish the fact that men of even larger stature were by no means unusual.

Instances of excessive corpulency have been common among Hawaiians, especially among the chiefs who were always better nourished than were the common people. Having plenty to eat and little to do, they grew large and fat. This tendency to corpulency, as has been elsewhere noted, was, however, more common among the women. Many of them were perfectly enormous in size, but this is not to be wondered at since the Hawaiian ideal of female loveliness includes stoutness of figure as a fundamental requisite.

The natives, before their mixture with foreigners, were a brown race, varying in color from light olive to a rich swarthy brown. Their hair, usually raven black, was straight, wavy or curly, but never kinky. Their lips were of a little more than medium thickness, with the upper lip slightly shortened. This gave to the mouth a peculiar form that is characteristic of the race. Their teeth were sound, regular and very beautiful, a fact frequently ascribed to the character of the food they ate. The nose, a rather prominent feature, was in most cases broad and slighty flattened. The eyes of the pure-blooded Hawaiian were always black and very expressive. Their foreheads were usually high, and perhaps a trifle narrow in proportion. In general, their features were strong, good-humored, and in many instances, when combined with their splendid physiques, produced a striking and impressive personality that gave the impression of their belonging to a very superior race.

Clothing of the People.

At the time of their discovery the men wore the malo, a plain piece of tapa cloth, about the loins in the form of a T bandage. The women wore the pa'u of tapa, which was a simple piece of bark cloth, wrapped about the waist, to form a short skirt, that hung down to the knees. While the foregoing were the usual articles of dress they were by no means averse to answering the call of their environment by stalking about naked or nearly so, if a pretense offered. They were fond of certain kinds of adornment, particularly flowers, using them as garlands about their necks or as wreaths about their heads. The children while often wearing flowers about their necks, went otherwise unadorned until six or eight years of age.

Cleanliness.

Although the Hawaiians wore their tapa cloth clothing as long as it would hold together, the people as a whole took great pride in personal appearance and cleanliness. They were fond of ornaments and were skillful in their manufacture. Both sexes wore ornaments fashioned from shells, nuts and ivory about their heads and shoulders in addition to the flower garlands just mentioned. While tattooing was indulged in as a form of decoration its use in this respect was not carried to the extent that it was among the New Zealanders or

the Marquesians. Its principal use in Hawaii was to denote rank or lineage, to brand a slave or sometimes as a token of mourning.

Although the chiefs were markedly superior physically and otherwise, when compared with the common people, they were. nevertheless, descendants of the same race. The difference in stature and capability which they exhibited seems to have been the natural result of their environment. Being better fed, having more leisure, and relieved of the burdens of living and in many ways pampered and protected, they escaped the marks that exposure, excessive toil, hunger, fear and superstition invariably stamp on the less fortunate of every race.

Life in the Open Air.

The unusually salubrious Hawaiian climate stimulated the habit of out-of-door life, which was almost universal. The native huts were used chiefly as sleeping places and for protection from the rain. Their aquatic, athletic and sea-going habits were the growth of the open-air life they led. The love of frequent bathing, the nearness of the sea and the necessity of securing at least a part of their sustenance from the ocean, all combined in making them the most powerful and daring swimmers in the world and developed among them, perhaps, the world's most expert and intelligent fishermen.

Their Language and Alphabet.

Their language was singularly deficient in generic and abstract terms, but to make up for this general deficiency it was especially rich in specific names of places and things, most of which were derivitives that were full of meaning, frequently taking account of nice distinctions. Broadly speaking the Hawaiian language was little more than a simple tribal dialect of the Polynesian tongue that was spoken with much uniformity in a large number of the Pacific island groups. In fact, there is less variation in meaning and pronunciation of the language throughout Polynesia than exists today between the Spanish and Italian tongues. Besides the language of every-day life there was a style especially appropriate for oratory and another suited to the demands of religion and poetry. Since there was no written language, not even a picture language, at the time of which we write, one of the first acts of the American missionaries was to reduce their speech to writing. For this purpose only five vowels, a, e, i, o, u, and seven consonants, h, k, l, m, n, p, w, were found necessary. In the use of these twelve letters the European pronunciation of the vowels was adopted. The letter a is sounded as in arm; e as in they; i as in machine, and u as in rule. The dipthong ai, resembles the English ay, and au has the sound of ow. The consonants were sounded as in English except that k is sometimes exchanged for t, and the sound of l confounded with k and d. The dirth of consonants and the over-plus of vowels gave to the spoken language such openness, fluidity and richness as to be particularly noticeable to persons unacquainted with the tongue. By some this peculiar quality of the spoken language, by reason of its intellectual indefiniteness, perhaps, is believed to represent, or at least reflect, the open, frank character of the people who developed it.

PLATE 5. HAWAIIAN HOME LIFE.

(For Description of Plate See Opposite Page.)

Genealogy and History.

Their legends and traditions, many of them identical with those found in other groups in Polynesia, as has been stated, were handed down, generation after generation, by a highly honored class of genealogists and bards. Each family or clan had its respected historians and poets, and generally the position of genealogist, at least, became hereditary, to be handed down from father to son. It was the especial office of the genealogist to keep and correctly transmit the historical records of chiefly unions, births, deaths and the achievements of the more important people of their community.

In this way much of the history of the people, as well as many of their legends and much of their historical beliefs, superstitions and practices, have come down to us in fairly accurate form, often from very remote times.

Meles and Hulas.

Their meles and hulas were the supreme literary achievements of the ancient historians and poets, and, as their subjects were diverse, they vary much in substance and character. Many are folk songs; some are of a religious order, being prayers or prophecies; others are name songs, composed at the birth of a chief, in his honor, recounting the exploits of his ancestors; the dirge was a favorite form of composition; others again are mere love songs, and still others are composed to or about things and places.

Although they are without rhyme or regular meter, as it is generally understood, many of them are strikingly poetic in spirit. A single example taken almost at random from the many excellent translations given by my friend, Dr. N. B. Emerson, in his book on the Hula, may serve to illustrate their appreciation of the poetic side of nature as well as to demonstrate their natural descriptive power and literary gift.

By way of introduction, we should know that Koolau is a district on the windward, or rainy, side of the Island of Oahu and that the stanza given is one taken from one of the many songs for the hula ala'a papa. It is but an episode from the story of Hiiaka on her journey to Kauai to bring the handsome prince Lohiau to the goddess Pele. Hence,—

"'Twas in Koolau I met the rain;
It comes with lifting and tossing of dust,
Advancing in columns, dashing along.
The rain, it sighs in the forest;
The rain, it beats and whelms like the surf;
It smites, it smites now the land.
Pasty the earth from the stamping rain;
Full run the streams a rushing flood;
The mountain walls leap with the rain.
See the water chafing its bounds like a dog,
A raging dog, gnawing its way to pass out."

Description of Plate.

1. The nose flute player and hula dancer. 2. Hawaiian house on a raised stone platform. 3. Making fire by the ancient Hawaiian method: a hard stick of Olomea (*Perrottetia Sandwicensis*) is rubbed in a groove on a soft piece of hau wood until the friction ignites the tinder-like dust that accumulates in the end of the groove. 4. A temporary house made of sugar-cane leaves. In the foreground taro and tobacco are shown, to the left a papaya, while in the background lauhala, banana, breadfruit and cocoanuts may be seen.

Many find a suggestive parallelism of expression in the Hawaiian meles comparable with the Hebrew psalms, others to the rugged poetry of Walt Whitman. No better illustration of this dignified form of Hawaiian poetry can be found, perhaps, than the passage from the dirge, "In the Memory of Keeaumoku," as preserved by the Rev. William Ellis:

"Alas, alas, dead is my chief,
Dead is my lord and friend;
My friend in the season of famine,
My friend in the time of drought,
My friend in my poverty,
My friend in the rain and the wind,
My friend in the heat and the sun,
My friend in the cold from the mountain,
My friend in the storm,
My friend in the calm,
My friend in the eight seas,
Alas, alas, gone is my friend,
And no more will return."

As so frequently happens with people gifted with a lyric talent, the Hawaiians were also possessed of an extraordinary musical talent. There were many among them at the time of their discovery that sang with skill, after their own fashion, and they were by no means slow to acquire the technique of our own more intricate written music, a fact which soon revolutionized their form of musical expression.

Marriage.

Passing now to the more domestic customs of the people it may be said that among the Hawaiians, marriage was entered into with very little ceremony, except, perhaps, in the case of a few of the more important chiefs. Among all classes the relations among the sexes were very free and it is difficult to determine, with accuracy, what the exact condition was originally with reference to chastity. All the evidence goes to show that the habits of the people in this regard were far better formerly than they afterwards became. Whatever may have been brought about by the coming of white men, and we refer to the hardy seamen of the early days, it is a mistake to assume that wholesale promiscuity existed originally among them comparable to the debasing type found among certain classes in our own scheme of social civilization. Although there was much freedom on the part of both parties in the marriage relation and scarcely any restraint at all among the young previous to entering the more settled domestic arrangement, it is an error to suppose that there was an absence of a definite marital relationship, accompanied by well understood obligations between the parents and their offspring.

Polygamy.

By such Hawaiians as could afford and command more than one wife, polygamy was practiced to some extent, rather more as a mark of distinction

and affluence than otherwise. The poor and dependent condition of the mass of the common people, if there had been no other reasons, prevented the practice from becoming widespread among them. It is a curicus and interesting fact in this connection to note that the Hawaiian called all of his relatives of the same generation as himself "brothers" and "sisters," and those of the next older—"fathers" and "mothers"; those of a younger generation "sons" and "daughters," and so on. This tendency is taken by some as indicative of the uncertain relations that existed among them, since brothers, to a certain extent, shared their wives in common, and sisters their husbands. But the marital form, where one man and one woman habitually cohabit, while yet indulging in other attachments, was the rule among them at all times and in all classes as is clearly shown by the earliest recorded facts on the subject.

It is known that in certain instances betrothals were arranged by parents and friends while the children who were the principals in the arrangement were still quite young. Among the common people, as distinguished from the chiefs, marriage was largely a matter of caprice, but among the chiefs it was a subject of serious concern, involving matters of state, public policy, position and power. Especially was this true at the mating of women of rank, since rank, position and inheritance descended chiefly, though not wholly, through the mother. For example, the offspring of a woman of noble birth would inherit her rank despite the rank of the father. But the children of a father of high rank would fail to retain their position if born to a woman of inferior position.

Marriage Among Persons of Rank.

For this reason reigning families were careful to examine into the genealogy of those who were liable to join themselves with members of the more exclusive families. For reasons of policy brothers were forced on rare occasions to marry sisters, that there might be no question as to the rank of their children.

While there was no set wedding ceremony the event was often made an excuse for a feast; and frequently, particularly among the common people, the bridegroom declared his choice by throwing a piece of tapa cloth over the bride in the presence of her relatives, or less frequently by their friends throwing a piece of tapa over both bride and groom. It is an astonishing fact, that with the exception of marriage, almost every act in the life of the people was celebrated with prayers, sacrifices and religious ceremonies. It cannot be doubted, therefore, that the marriage tie was a loose one, lightly assumed and lightly put off, and depended largely for its duration on the will of the husband. As might be expected, separation was of frequent occurrence among them; and while fond of their children, after time had given opportunity for an attachment to develop between parent and child, it was never-the-less a widespread practice among them, for mothers to part with their babies at birth, giving them freely and without reserve to relatives or friends who might express a wish for the child.

Infanticide.

There can be no doubt but that infanticide was prevalent among them and

PLATE 6. HAWAIIAN TYPES.

(For Description of Plate See Opposite Page.)

that a very large per cent of the children born were disposed of in various ways by their parents, soon after their birth. Generally speaking, it appears that in Hawaii, as throughout Polynesia, the struggle for existence and life's necessities, was largely evaded by restricting the natural increase in population in this way. Whatever the cause may have been for this unusual restriction, it is quite generally admitted to have been an effective one so far as keeping the population down to where a comfortable subsistence could be had by all who were permitted by their parents to live past the perilous period of early infancy. From the purely economic point of view this artificial check was most beneficial. Freed from crowding by overpopulation, the primitive community need not live under the scourge of grinding poverty. By limiting the size of the family to the means and ability of the parents to provide, there could be enough for all. Direct reasoning led them, therefore, to free themselves from the irksome necessity of providing more or dividing less, by restricting the increase in population to a point well within the apparent normal food supply. My friend, Dr. Titus Munson Coan, without upholding the crude methods employed in adjusting the two important factors mentioned, finds the freedom which the people enjoyed from the necessity of providing, to be the main cause of the unusual development of the genial and generous traits of the Hawaiians, and in it finds the principal source of their marital happiness. Other writers account for the practice of infanticide among the Hawaiians on the unpardonable ground of laziness—unwillingness to take the trouble to rear children. But as we are told that parents were fond of their children and parental discipline was not rigorous, and as children were left largely to their own devices, their care could hardly be regarded as a serious burden; moreover, more girl children were destroyed than boys, indicating that the former reason was the more economic and therefore the more human and logical one. On the other hand it may be urged that a certain amount of brutality was always exhibited toward their own kind. The old and physically unfortunate among the common people fared roughly at the hands of the community. Old age was despised. The insane were often stoned to death and

DESCRIPTION OF PLATE.

1. A sturdy old native in characteristic European dress. 2. The Hawaiian warrior Kamehameha I. From a monument in front of the Judiciary Building in Honolulu, erected, during the reign of King Kalakaua, one hundred years after the discovery of the Hawaiian Islands by Captain Cook. The statue, by an American artist, is a composite, based on a painting of Kamehameha by a Russian artist and supplimented by photographs of the finest types of modern Hawaiians. The figure is shown wearing the helmet [mahiole] made of wicker-work covered with feathers; a long cloak [ahuula] of feathers attached to a fine net work of olona; about the chest and over the shoulders is draped the malo of Umi, also made of feathers on an olona foundation. About the loins is tied the common tapa malo—the covering worn by the men of ancient Hawaii when at work; in the left hand is the spear [newa], the chief implement of warfare. The Honolulu statue is a duplicate of the original which was lost in a wreck on the voyage to Honolulu. The sunken statue was subsequently raised and now stands in the court yard at Kohala, Hawaii. Four pictures in bas-relief about the base of the monument (not here shown) represents (a) canoes greeting Captain Cook at Kealakekua Bay; (b) six men hurling spears at Kamehameha; (c) a fleet of war canoes built for the invasion of Kauai, and (d) men and children on the roadside. 3. Muscular young Hawaiian.

the sick sometimes left to die of neglect or, less frequently, were put to death by their relatives.

Descent of Rank.

While the descent of rank through the female line gave women a place of unquestioned importance in their social scheme and often elevated her to the highest positions in the political order, it did not save her from certain forms of social degradation directed irrevocably at all her sex. For example, her sex was excluded from the interior of their chief heiaus. At birth she was more unwelcome than her brother and more liable to be summarily sent to the grave. She was the object of the most oppressive of the regulations of the tabu system. She must not eat with men or even taste food from an oven that had been used in preparing food for them. She was not allowed in the men's eating houses, and several of the choicer food products of the islands were absolutely forbidden her. Such delicacies, for example, as turtle, pork, certain kinds of fish, cocoanuts and bananas, were reserved by the tabu for the exclusive use of the male sex. But as a sort of compensation the men attended to the preparation and cooking of the food, and women were allowed the privilege of accompanying and aiding their husbands and brothers in battle. They could manufacture bark cloth without fear of competition by the men, and they could engage in the practice of medicine, as they understood it, on equal terms with the sterner sex.

The Tabu.

Reference has just been made to their tabu system. A cursory examination of it will show what a far-reaching, serious and exceedingly complicated system of penal exactions and regulations it was. No one, not even the king, was altogether free from its influence, and the common people were made to bow to its dictation at every turn of their daily lives. As an institution, the system was both religious and political, in that the violation of the tabu[1] was a sin as well as a crime. As a punishment for its infraction the offender was liable to bring down the wrath of the gods, and they were numerous, as well as bring about his own death, which was often inflicted in an exceedingly cruel and barbarous manner. This extraordinary institution, although common throughout Polynesia, was worked out to a finer detail, and more sternly enforced in Hawaii, perhaps, than in any of the Pacific islands. For the present purpose it would be tedious to sketch the system in anything more than a general way. Suffice to say that the tabu was the supreme law of the land. In its final analysis it was a system of religious prohibition founded on fear and superstition, the interpretation and use of which was in the hands of a powerful and unscrupulous priesthood, the kahunas, who in their palmy days were supported with all the physical power that the kings and influential chiefs could bring to bear.

Some of the tabus were fixed and permanent, being well understood by all the people. Many such there were relating to the seasons, to the gods and to

[1] That which was forbidden.

oft-repeated ceremonies. Others were special, temporary and erratic, having their inception in the will or caprice of the king or the pleasure of the kahunas. Some of the more burdensome were specific and directed against certain persons or objects. For example, the persons of the chiefs and priests were tabu [2] as were the temples and the temple idols. Some in effect were exceedingly rigid requirements, others partook more of the force and importance of regulations. There were four principal tabu periods during each month. During these periods a devout chief was expected to spend much time in the heiau.[3] At such times women were forbidden to enter a canoe or have intercourse with the other sex until the tabu was lifted. An especial edict made it incumbent that during the whole period of her pregnancy the expectant mother must live entirely apart from her husband, in accordance with a very ancient tabu. At the periods sacred to the great gods many were put to death for infractions of the tabu, as many restrictions were promulgated and enforced at such seasons, and, through ignorance, the people were liable to disregard them.

We are informed by the people and through the records of early visitors that at such times no person could bathe, or be seen abroad during the day-time, no canoes could be launched, no fires were allowed, not even a pig could grunt, a dog bark or rooster crow for fear the tabu might be broken and fail of its purpose. Should it fail the offenders were made to pay the penalty with their lives.

Any particular place or object might be declared tabu by the proper person by simply affixing to it a stick bearing aloft a bit of tapa, this being a sufficient sign that the locality was to be avoided. The bodies of the dead were especially sacred objects and always tabu. As long as the body remained unburied it was subject to the vagaries of the system. Those who remained in the house or had to do with the corpse were defiled and forbidden to enter other houses in the village.

Owing to the tabu, two ovens must be maintained, one for the husband, the other for the wife; two houses must be built to eat in, a third to sleep in. In a thousand similar ways the system was fastened on every act of the daily life of the people to such an extent that it was ever present, dominating their every thought and deed. It oppressed their lives, curtailed their liberties, and darkened and narrowed their horizon beyond belief.

CHAPTER IV.

THE RELIGION OF THE HAWAIIANS: THEIR METHODS OF WARFARE AND FEUDAL ORGANIZATION.

Complex and bewildering as was the Hawaiian system of tabus, their religious system was even more so. Moreover, the one was so intertwined with the other that the two subjects cannot be treated separately. Since the Ha-

[2] Sacred. [3] Temple.

PLATE 7. HEIAUS, WAR CANOES AND A CITY OF REFUGE.

(For Description of Plate See Opposite Page.)

waiians were naturally a highly religious people, they found many objects to worship and many ways in which to worship them. As a matter of fact, the earth, the sea and the air were filled with their amakuas, in the form of invisible beings, who wrought wonders in the powers and phenomena of nature. The presence and power of the amakuas was evidenced to them by the thunder, lightning, wind, earthquakes and volcanoes.

Religion Among the Hawaiians.

Of the innumerable gods in the pantheon, Ku, Kane, Lono and Kanaloa were supreme. These important gods were supposed to exist in the heavens, in invisible form, and to have been present at the beginning. They were also believed to appear on the earth in human form. In addition to these each person had his or her own titulary deity, and each occupation was presided over by a special amakua, to which worship was due. Thus the fisherman, the canoe maker, the hula dancer, the tapa maker, the bird catcher, even the thieves and the gamblers, all had presiding deities with power to prosper them in their callings and bring them good luck in their undertakings. Other deities were clothed in life in the form of numerous animals and plants. Disease and death were quite naturally regarded as the work of the gods and appreciated by the people as material evidence of their invisible powers.

Idol Worship.

They worshipped their deities chiefly through idols made of wood or stone. They believed that such images represented, or in some way were occupied by the spirit of the deity that they sought to worship.

The people as a whole had a rather well defined conception in regard to existence after death. They believed that each person had an invisible double. They also thought that after death the spirit lingered about in dark places in the vicinity of the body and was able to struggle in hand to hand encounters with its enemies. A nightmare was interpreted as a temporary quitting of the body by the spirit and in certain cases, through proper prayers and ceremonies, it was believed to be possible to put the soul back into the body after it had left it. This was usually accomplished by lifting the toe-nail of the unfortunate person concerned. Many places were believed to be haunted and the spirit was supposed to journey from the grave to its former abode along the path that the corpse was carried for burial.

Description of Plate.

1. The Heiau of Puukihola at Kawaihae—a huge stone enclosure built by Kamehameha I. as a protection against the perils of war. Many human sacrifices were made on its altar to the great war god Kukailimoku; among others the bodies of Kamehameha's rival, Keoua, and his followers who, on a peace mission, were treacherously slain while landing at Kawaihae from a canoe in the year 1791. 2. Entrance to the Heiau at Kawaihae. 3. Double war canoe equipped with mat sails; the gourd masks worn by the warriors are also shown. 4. Feather cloak [ahuula] worn by chiefs of importance; made of red [iiwi] and yellow [mamo and o-o] bird feathers. 5. The city of refuge [puuhonua] at Honaunau; a stone wall twelve feet high and fifteen feet thick encloses seven acres of tabu ground. To such sanctuaries women and children, warriors worsted in battle, criminals and others in peril might flee for safety from their avengers. 6. Heiau of the open truncated pyramidal type; compare with the rectangular walled type shown in figs. 1 and 2.

The Future State.

They had a rather indefinite notion as to the exact nature of the future state. However, they believed that the two usual conditions, misery and happiness, existed. If the soul after journeying to the region of Wakea[1] was not favorably received, it was forced through despair and loneliness to leap into the abode of misery, far below. Precipices from which the souls of the unhappy departed were supposed to plunge on this wild leap are occasionally pointed out at various places about the group. One at the northern point of Oahu, another at the northern extremity of Hawaii, and a third on the western end of Maui are well known to those acquainted with Hawaiian superstition.

Heiaus.

In order to propitiate their gods, or better accomplish their worship, the people through fear or at the command of the king or priests, erected numerous temples or heiaus. To many students of the race this blind fear of their gods and their chiefs, and their unreasoning acceptance of the tabu, are subjects of continual wonder. Their principal temples were of two general forms, the older being composed of rough stones laid up without mortar in the form of a low, truncated pyramid, oblong in shape, on top of which were placed the altar of sacrifice, certain grass houses, the idols of the temple and the other grotesque wooden images and objects used in their worship. The later and more common form of heiau was made by erecting four high walls of stone, surmounted with numerous images, enclosing a space occupied, as before, by the various images, oracles, sacred places and altars of worship. These temples were numerous in the more thickly settled regions on all the islands and were usually built near the shore. On Hawaii, in the region from Kailua to Kealakekua, particularly, they were very numerous and close together. The principal heiaus were dedicated to their chief gods, but many smaller ones were built, as fish heiaus, rain heiaus and the like, and were dedicated to the special god of the builder.

Where temples were found in large numbers a corresponding number of priests were to be expected. Of these there were many orders and sub-orders. They and their rights were constantly made use of by the chiefs for the purpose of terrifying the people. Through them the tabu was coupled with idol worship, and their combined cruelties, terrors and restrictions made an integral part of the general system of government.

Warfare.

War among the ancient Hawaiians was one of the chief occupations and with them, as with other races, war was the "sport of kings." In making preparations for war the king, however, in addition to the council of his chiefs, had the advantage of the advice and skill of a certain class of military experts who were instructed in the traditions and wisdom of their predecessors. Being

[1] The home of the reputed father of the race, a place provided with houses, food, consorts and pleasures.

well acquainted with the methods of warfare that had been successfully resorted to by kings in former times, they were at all times among the king's most respected advisors.

Fortifications, as we understand them, were not a part of their scheme of warfare, though sites for camps and defences were selected that possessed natural advantages in the matter of their defense against the enemy. That part of the population not actually engaged in battle was sent to strongholds, usually steep eminences or mountain retreats. In case of a rout the whole army retired to these strongholds and valiantly defended them. In addition to these natural forts, there were temples of refuge or sanctuaries to which those broken in battle, or in peril of their lives in time of peace, might flee and escape the wrath of all powers without. These temples were crude though permanent enclosures, whose gates were wide open to all comers at all times.

The Hawaiian warriors had many methods of attack and defense, depending usually on such matters as the strength of the enemy, the character of the battlefield and the plan of campaign. Their battles were generally a succession of skirmishes, the whole army seldom engaging in a scrimmage. They usually, though not always, made their attack in the daytime, generally giving battle in open fields, without the use of much real military strategy. Occasionally inter-island wars occurred in the form of naval battles in which several hundred canoes were used by both sides, but as a general thing their differences were settled on land.

Practically the entire adult population was subject to a call to engage in hostilities. Only those who were incapacitated through age or from infirmity were exempt from the summons of the recruiting officer sent out by the king to gather warriors, when anything like an extensive military operation was determined upon. If occasion required, a second officer was sent to forcibly bring to camp those who refused to answer the call of the first. As a humiliation and mark of their insubordination it was a custom to slit the ears of the offenders and drive them to camp with ropes around their bodies.

Preliminary to a Battle.

The army stores were usually prepared beforehand, and each warrior was expected to bring his own provisions and arms. Not infrequently notice of an impending attack was sent to the opposing forces and a battlefield mutually satisfactory to both forces selected for the engagement. The women took an active share in the important part of the work connected with the commissary; often following their husbands and brothers onto the battlefield, carrying extra weapons or calabashes of food. When the forces were assembled and all things in readiness for the fray, an astrologer was consulted by the king. If the signs were auspicious the battle would be undertaken. As the opposing armies approached each other, the king's chief priests were summoned to make the king's sacrifice to his gods. Two fires being built between the armies, the priests of each army made an offering, usually a pig, which was killed by strangling. When the various religious ceremonies were over the battle would begin,

PLATE 8. BURIAL CAVES, WAR GODS AND IDOLS.

(For Description of Plate See Opposite Page.)

the priests accompanying the armies, bearing their idols aloft—that the bodies of the first slain in battle might be properly offered to the gods. Their idols took the place of banners. During the heat of battle they would be advanced in the midst of the warriors, while the priests, supporting them, to cheer their followers and spread terror in the hearts of the enemy, would give blood curdling yells accompanying them with frightful grimaces, all of which were supposed to come from the images themselves, and to be an unmistakable token that the gods were in their midst.

In opening the attack, it is related, a single warrior would sometimes advance from the ranks, armed only with a fan and when within hailing distance would proceed to blackguard the enemy, daring them to attack him single-handed. This exasperating challenge would be answered by a number of spears being hurled at the taunting warrior, who would nimbly avoid them or seize them in his hands and hurl them back at the enemy. Such incendiary manoeuvers were well calculated to precipitate trouble and not infrequently they resulted in the death of the intrepid warrior. A fierce struggle would then follow to gain possession of his body.

Their battles were often almost hand to hand encounters, lasting sometimes for days. However, they do not seem to have been very fatal. Often they resulted in routing one party or the other, the conquerors taking possession of the land and portioning it out among the victorious chiefs. A heap of stones was made over the bodies of the victorious dead, while the vanquished slain were left unburied. Captured warriors were occasionally allowed their freedom, but more frequently they were put to death or kept as future sacrifices. The women and children of the captured were made slaves and bound to the soil.

When peace was sought a branch of ki leaves or a young banana plant was borne aloft by the ambassadors as a flag of truce. When terms were arrived at a pig was sacrificed and its blood poured on the ground as an emblem of the fate of the party to the treaty who should break its conditions. The leaders of both armies would then braid a lei of maile and deposit it in a temple as a peace offering. The heralds were then sent running in all directions to announce

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DESCRIPTION OF PLATE.

1. Typical Hawaiian burial cave. The common people after death were usually secreted in caves in the neighborhood; the burial took place during the night. Great care was taken, however, to hide the bones in secret places to prevent them from being used for fish hooks and arrow points. The important bones of the kings, including the skull, leg and arm bones, were gathered from the decayed flesh, collected into a bundle, wrapped with tapa and bound up with cord; the bundle was then deified by elaborate ceremonies before the bones were placed in the most secret and inaccessible caves, often being carried from one island to another. The bones of a high chief were preserved in vault-like caves in the cliffs and not infrequently were laid at rest in the warrior's canoe together with other precious possessions belonging to the departed. 2. An aged kahuna. 3. Kukailimoku, the god of war; taken from a figure in Cook's Voyages; other representations of this god are on exhibition in the Bishop Museum. 4. Burial cave (near view of fig. 1) showing a "transition" burial in a coffin hewn from a log. 5. Burial cave showing portion of a canoe, mats, tapa, etc. 6. Ancient wooden idol. Prior to the landing of the missionaries idolatry was abolished and the idols of the nation hidden away in caves; later many of them were collected and burned. A number, however, were preserved and are now in museums in Hawaii, America and Europe.

the termination of the war, and the event would be appropriately celebrated with feasts, dancing and games.

The King and His Power.

The king was the recognized head of all civil and military, also ecclesiastical authority. The lands, the people, their time, their possessions, the temples, the priests, the idols, the tabus, the prophets, all belonged finally to him. Everything was his to use as he willed so long as he was in the favor of the gods. The priests, who were the only ones skilled in interpreting the oracles and learning the wishes of the gods, were also the class which determined the offerings that would placate the deities worshipped. In this way, through fear, they were able to hold no small amount of influence over the affairs of state by reason of the king's dread of the wrath of the gods of his realm.

The high priest kept the national war god and was at all times in close relation to the monarch. Other priests were charged with perpetuating the traditions of the people as well as their own medical, astronomical and general learning. Besides the regular orders of priests there was a numerous class of more irregular priests or kahunas, that were little more than sorcerers. They were able to cause the death of persons obnoxious to themselves, their clients, their chiefs or their king.

In order to pray any person to death it was only necessary for one of their kahunas to secure the spittle, the hair, a finger nail, or personal effects belonging to the intended victim, and, by means of certain rites, conjurings and prayers to the gods, to so work upon the fear and imagination of the individual as to almost invariably cause his death. As a result they were unpopular as a class and not infrequently were conspired against by the people, or themselves prayed to death by the more powerful of their cult.

The Nobility, Chiefs and Common People.

In the time of which we write the population was divided into three classes, the nobility, including the kings and chiefs; the priests, including the priests, sorcerers and doctors; and the common people, made up of agriculturists, artisans and slaves taken in war. There was an impassable gulf between the class including the chiefs and the common people.

The distinction was as wide as though the chiefs came from another race or a superior stock, yet as we have said elsewhere they were undoubtedly all of one and the same origin with the people under them. A common man could never be elevated to the rank of a chief, nor could a chief be degraded to that of a commoner. Hence the rank was hereditary in dignity at least, though not necessarily so as regards function, position or office. Within the class of the nobility, sharp distinctions were numerous and a certain seniority in dignity was maintained. As far as can be learned there was no distinction between civil, military, ecclesiastical and social headship, and there was no separation between the executive, judicial and legislative functions. The power, in an irresponsible way, was entirely centered in the hands of the nobility.

Since the chiefs were believed by the common people to be descended from the gods in some mysterious and complicated way, they were supposed to be in close touch with the invisible powers. They were looked up to with superstitious awe, as being both powerful and sacred. This advantage was shrewdly employed by the ruling class in securing the respect and unquestioned submission of the common people. Death was the penalty inflicted for the slightest breach of etiquette. Through the enforcement of such submission the chiefs were able to exact the marks of distinction claimed by them from the masses, and to control and direct them through a blind rule of duty. Singularly enough the chiefs were respected while living and in most cases were revered by the people after their death.

Among the chiefs themselves there was constant bickering and class rivalry. The moi, or king of each island usually inherited his position, but the accident of birth did not guarantee that he would long remain in power, for unfortunately the assurance of his place lay in the hands of the district chiefs under him. Seldom could they be relied upon for unshaken fealty. Their love of power and capacity for intrigue, as a rule, was not of a common order and they were often able to demonstrate their complete mastery of the game of politics.

The important chiefs were therefore usually summoned by the king to sit in council as an advisory body when weighty matters were to be passed upon. But the immediate source of all constructive law as such, among the ancient Hawaiians, was the will of their king. Not unlike kings in more enlightened lands, they were guided in important matters by their stronger chiefs whose influence they required. These, in turn, were influenced by and dependent upon the good will of the people under them, for there was nothing to prevent the common people from transferring their personal affections and allegiance to other and more considerate chiefs. But back of the king, the chiefs, and the people was the traditional code of customary law that served as a powerful restraint on the king in preventing the promulgation of purely arbitrary decrees. The traditional law of the land related mostly to religious and customary observances, marriage, the family relation, lands, irrigation, personal property and barter. With such crimes as theft, personal revenge was the court of first resort. The aggrieved person had the right, if he so desired, to seek the aid of a kindred chief, or to resort to sorcery with the aid of his kahuna. The king, however, was the chief magistrate, with his various chiefs exercising inferior jurisdiction in their own territories.

The King and the Land.

The king was regarded as the sole proprietor of the land; of the people who cultivated it, the fish of the sea,—in fact everything on the land or in the sea about it was the property of the king. The king, in short, owned everything, the people owned nothing, so that technically, the people existed in a state of abject dependence. The system that developed from this was one of complete

and absolute feudalism. The king made his head chiefs his principal beneficiaries. They, in turn, established a grade of lesser chiefs or landlords, who gathered under them the common people as tenants at will. The lands being divided, those who held the land owed every service and obedience to the chieftain landlords. On these landlords the king relied for men, labor, munitions and materials to carry out his plans and fight his battles.

TAXES.

This system was so offensive that it is said that the laborer did not receive one-third the returns due him for his toil; the lion's share of everything, even in this simple system, went to the over-lords, in the form of a tax. There was first, the royal tax that was collected by each grade paying to its superiors until the whole tax, which consisted of such articles as hogs, dogs, fish, fowl, potatoes, yams, taro, oloná, feathers, and such articles of manufacture as calabashes, nets, mats, tapas and canoes, was collected. In addition to the foregoing, the people were subject to special taxes at any time, and labor taxes at all times, when they were called upon to build walls, repair fish ponds, cultivate the chief's taro ponds, or construct or repair the temples.

Besides all these, and other means of taxing the people, there were customs which made it necessary to make extraordinary presents to the king, especially when that dignitary was traveling, with the penalty that if enough presents were not brought, plunder and rapine was the consequence. With this hasty review of some of the more general and especially interesting or striking peculiarities of the Hawaiian people, as a branch of the Polynesian race, that are of importance as salient characteristics when we wish to compare them and their natural human history with that of other races of mankind, we can now pass to a brief review of their arts, occupations, ornaments, weapons, tools and kindred subjects in which they made use of the materials with which nature surrounded them.

CHAPTER V.

THE HAWAIIAN HOUSE: ITS FURNISHINGS AND HOUSEHOLD UTENSILS.

The houses of the common people were little more than single-room straw-thatched hovels, supported upon a crude frame-work of poles, the structure in many instances being scarcely sufficient to shelter the family. On the other

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(Description of Plate Continued from Opposite Page.)

woven over a wooden umeke or a gourd-calabash, a fine Niihau [makaloa] mat, a sled [papa holua] for coasting on the grass on steep hills and two spears; in 2 are a number of small objects including gourd water bottle [huewai], small idol, canoe model, bowling stones [ulumaika], Hawaiian brick shaped pillows [uluna], gourd hula drum [pahu hula], three large and several small umekes, fans, a feather malo or waistband and a large and small kahili; in 3 the old Hawaiian keeper [kahu] is surrounded by numerous objects of native manufacture, including poi pounders [pohaku kui poi], kukui nut and feather leis, the famous skirt [pa-u] of o-o feathers (made for the sister of Kamehameha III. and last used over the coffin of Kalakaua) and two large and two small kahilis; in 4 are three large umekes in nets [koko], a carrying stick [auamo], a gourd fish line container [poho aho], several choice umekes, rare tapas, kukui nut leis and a small kahili.

PLATE 9. PORTION OF THE HAWAIIAN GOVERNMENT COLLECTION.
(Now Deposited in the Bishop Museum.)

Among other objects shown in 1 are three large wooden calabashes [umeke] of flat form on a fine lauhala mat; four kahilis of various forms; a wicker-work basket [hanai poepoe]

(Description of Plate Continued on the Opposite Page.)

hand, the houses of the better class, notably the chiefs and the nobility, were much superior. Being well built and neatly kept, they were not so devoid of simple comfort as their absolute lack of architectural beauty might suggest.

While their houses varied much in size and shape they were uniformly dark and poorly ventilated, being invariably without windows or doors, save the small hole left, usually on one side, through which the occupant might pass in and out in a crouching posture.

Complete Domestic Establishment.

As with the various occupations that had to do with the gathering of their food and the making of their raiment, so the building of the house which sheltered them was attended by many important religious observances, the omission of any of which might result in the most serious consequences. Every stage, from the gathering of the timbers and grass in the mountains, to the last act of trimming the grass from over and around the door before it was ready for final occupancy, furnished an occasion for the intervention of the priests and the imposition of special tabus that must be satisfied before the house could be used as a dwelling.

As has been suggested elsewhere, a complete domestic establishment was made up of several conveniently grouped single-room houses that were given over to special purposes. The well-to-do Hawaiian boasted of at least six such single-room houses. The house for the family idols and the men's eating house were both always tabu to women. The women's eating house, a common sleeping house, a house for the beating of the tapa, and lastly, a separate house for the use of the women during various tabu periods made up the group. Occasionally the better houses were on a raised stone foundation, and a fence made about the group to separate them from their neighbors and to mark the limits of the sphere of domestic influence. To the foregoing might be added a house for canoes, a storehouse, and others for special purposes as might be required.

Building of a House.

The building of a grass house of the better type was an important task and one that called for much skill and experience. The timbers of which it was constructed were selected with great care, different woods being preferably used for certain purposes. When trimmed of the outer bark, notched and fashioned into shape by crude stone tools they were placed into the positions which they were intended to occupy in the framework of the structure and then firmly bound together with braided ropes of ukiuki grass.

The corner posts were first to be put in place, each being securely set in the ground. The side posts were next planted in line and the plate pole lashed to the top. The tall poles at the end of the house were next put up and the ridge pole put into place. The rafters were then added and the upper ridge pole lashed firmly above the main ridge pole. Small straight poles were finally lashed horizontally, a few inches apart, on the outside of the completed frame-

work. This done the thatch was added and a rude sliding door made and fitted in place. The outside was trimmed, and over all a large net placed to hold the grass in shape while it dried. Pili grass, lauhala leaves, sugar-cane and ki leaves were used as a thatch according to circumstances. When completed a group of Hawaiian houses resembled nothing as much, in general appearance, as a number of neat hay stacks.

While as a general rule each man was expected to be able to perform all the various forms of labor necessary to the building of a house, making a canoe or carving his dishes, there were those who by choice did certain things in exchange for the work of others. That is to say, should a chief order a house built, certain men would cut the timbers, others gather the pili grass, others hue the timbers, while still others made the binding cords or prepared the holes for the corner posts. The thatchers would then perform their work, so that by piece work, all working together, a house could be completed in two or three days. If well made it would last a dozen years,—when it would require re-thatching

House Furnishings.

The furnishings and utensils in even the best houses were meager in the extreme. The raised portion of the floor, covered with mats that formed the beds by night and lounge by day, and the space on the stones in the center of the floor, that served as a fireplace when required during rainy weather, were the most noticeable evidences of comfort. The braided mats and ornamented tapas were the most conspicuous among their possessions, but the bowls and dishes for the serving and storage of food were, perhaps, the most important household necessities. These few objects formed characteristic features of the Hawaiian home. The most valuable of their household utensils, without doubt, was the calabash. It was fashioned from wood or made from the shell of the gourd, for though clay was known to the Hawaiian people they made no use of it and knew nothing whatever of the potter's art.

In the carving of these wooden bowls or umekes they exhibited much skill, using only the simple stone implements of their culture and such primitive devices as they knew in fashioning them. Some wonderful bowls were produced from the woods of the native kou, kamani and the koa trees. After the log had been soaked for a long period it was roughly shaped without and was hollowed out within by hacking and burning until the desired form was secured. By this method the wooden sides were reduced to a fraction of an inch in thickness. The receptacle was then smoothed by rubbing first with coral, then rough lava, and lastly with pumice. The real polishing was done by rubbing with charcoal, bamboo leaves and at last with breadfruit leaves and tapa. Often a lid, made and polished in the same way, was added, and usually a koko or net of convenient form for carrying or handling them was provided. It may be truthfully said that the splendid vessels made in this way, some of them thirty inches in diameter, were among the most remarkable objects wrought by the ancient Hawaiians.

PLATE 10. HAWAIIAN TYPES AT WORK AND PLAY.

(For Description of Plate See Opposite Page.)

Household Implements.

In the manufacture of other household implements, as pig dishes, dog trays, fish dishes, finger bowls, slop basins and the like, the same tools and materials were used and the same general method of working them into shape was employed, though frequently they were carved or ornamented in various ways.

In the calabash gourd the Hawaiians had a substitute for the more laboriously prepared wooden bowl just described. While the calabash gourd is not a native of Hawaii and was not found on the other islands in Polynesia, it was in general use among the natives of this group at the time of their discovery and the shells of the fruit put to many uses in their economy, often being employed as receptacles for food, containers for water and storage boxes for clothing and personal effects.

A slightly different though equally useful species was the bottle gourd. Unlike the former, it was known and used quite generally throughout Polynesia. The smaller ones served as first-rate water bottles and the larger specimens were utilized in the manufacture of their hula-drums, which were sometimes three feet or more in height. Both species were extensively cultivated in the period of which we write. In preparing them for use the soft, bitter pulp was first scraped out as clean as possible and the shell allowed to dry. When it had become thoroughly hardened the remaining portion of the soft material was scraped out with a piece of pumice or a fragment of coral. They were then filled with water and left to stand until they had become sweet.

In making water bottles where the small neck did not admit of the preliminary scraping, the soft part was allowed to rot out. Then stones and sand were put inside and shaken about until the contents came away, leaving only the clean, hard outer shell. To the bottle was added a sea shell or folded palm leaf as a stopper, and the container was ready for use. The different forms often had different uses. When it was desired to carry them,—or indeed any heavy burden,—the larger gourds were usually provided with carrying nets of one form or another and suspended one on either end of a tough wooden carrying stick which was notched at each end.

Finger bowls were in general use among the Hawaiians long before they were introduced by the whites, and many ingenious devices were perfected by the natives to remove the sticky, pasty poi from their fingers. These bowls varied greatly in size, shape and design, but were generaly made from the kou.

Description of Plate.

1. A chiefess [alii] wearing a holoku; about the neck is shown a lei [lei palaoa] of braided human hair ornamented with a pendant ivory hook; in the hand is a small kahili with ivory and tortoise shell handle. The lei palaoa and the "fly flap" are both insignia of chieftainship. 2. Middle-aged corpulent Hawaiian; beside the poi board is shown the taro roots as they appear before baking. 3. Group of Hawaiian diving boys in Honolulu harbor. 4. Hawaiian woman plaiting a lauhala mat; beside her is a finished mat and a bundle of the lauhala leaves ready for use. 5. Ohulenui, whose father, as a boy, was familiar with the history and practices of worship at Iliiliopoi, the great heiau on Molokai in Mapulehu Valley. 6. A pure blood middle-aged Hawaiian surrounded by objects of more or less recent manufacture.

With the finger bowl at hand, into which the fingers might be dipped or the hands washed, and with a plentiful supply of fresh leaves as napkins, the absence of knife, fork and spoon from the Hawaiian table was not such a serious omission as it might at first seem. However, in certain parts of the group, as Puna, where a less tenacious poi was made from the sweet potato, a general utility implement was fashioned in the form of a generalized spoon from a fragment of cocoanut shell that served very well the combined purpose of spoon and ladle.

Other household implements for special use were made from the shells of cocoanuts. Besides serving many varied purposes they were chiefly useful as cups and were made in special forms as containers for awa.

The Hawaiian mirror was an ingenious device consisting simply of a polished piece of wood or a piece of smooth, dark-colored lava. In order to produce a reflecting surface it was dropped into a calabash of water. The image was thus produced on the surface of the water, or, if sufficiently polished, it could be used after immersion in the water. To trim the hair, a shark tooth firmly fastened in a stick was employed; or, if this method proved to be too painful, fire might be used instead. A fan of curious form, braided usually from the leaves of the pandanus or the loulu palm, was a convenience of ancient origin among the Hawaiians. The form, however, has been greatly modified in recent times. The back-scratcher, a scraper-like implement made of hard wood and provided with a long handle, was a decided comfort to the ancient Hawaiians, and they were in general and frequent use at the time of which we write.

In the evening artificial light was supplied by burning the nuts of the kukui, which were strung on slender strips of bamboo. The oil of these useful nuts was also pressed out and burned with a tapa wick in a stone cup or crude lamp. Occasionally the fat of the pig and dog was used as an illuminating oil.

Fire.

The Hawaiian method of lighting a fire was by the friction of two pieces of wood. A sharp hard stick was pressed firmly into a groove on a large and softer stick and rubbed up and down until the fine dust that rubbed off and accumulated in one end of the groove ignited from the heat of friction. When everything was properly managed only a few minutes were necessary to start the tinder and transfer the light to a bit of tapa or other inflammable material. The trouble incident to igniting a fire was obviated by carrying fire from place to place. To do this old tapa was twisted into a cord a third of an inch in diameter and rolled into a ball to be used when desired as a slow-burning torch. In this way a lighted fuse might be carried a long distance.

The Hawaiian broom was simply a conveniently-sized bundle of palm-stem midribs tied together. And since sweeping was not an exacting art, it served every purpose. While wooden pillows were used, oblong six-sided ones made of platted pandanus leaves were more common.

Small stones of different shapes for various domestic purposes were used, some for cooking birds, others as bath rubbers, and so on, but the principal use of stone in the household was in the manufacture of poi pounders and mortars, to which reference has been made in another chapter. Lastly, reference should be made to their wooden slop jars which were in common use as receptacles for refuse food, banana skins, fishbones and offal. While many of them were roughly made of kou, others were finished, and a few belonging to the chiefs were inlaid with the bones of their enemies or those whom they would dishonor.

CHAPTER VI.

OCCUPATIONS OF THE HAWAIIAN PEOPLE.

Agriculture Among the Hawaiians.

Agriculture was one of the principal occupations of the ancient Hawaiians and like almost everything they did, was accomplished by a set of more or less elaborate religious ceremonies. They were particular to plant in the proper time of the moon, and prayers were said, and offerings made and tabus kept during the various stages of the growth of the plant. When necessary, prayers were made for rain or to allay the wind, or to stop the ravages of insects, and at last when the crop was ripe, prayers of thanksgiving were said and appropriate offerings were made to the family gods.

The growing of taro was the chief industry among their farming activities, and the simple dishes manufactured from this plant have always been their principal and often only article of food. Two methods of planting were and still are followed. Where running water was to be had from the streams taro, or kalo, could be grown at all seasons, and only a scarcity of water could seriously influence the yield. Where water could be led onto the ground from the streams or be led to the fields by their primitive irrigation ditches, the crop was always in a flourishing state of growth. The work necessary to prepare the ground, plant, irrigate and cultivate the crop, then as now, formed the most laborious part of the native farming.

Taro Growing.

Considering the character of the country, the natives had arrived at a degree of skill in the cultivation of the useful taro plant that has been difficult to improve upon. After a century of contact with European ingenuity and learning, the crop is still cultivated in the ancient manner, with the exception that the primitive digger or oo, made of wood, has been supplanted by some of the more modern garden implements made of metal.

The taro ponds are usually small and irregular in form, and vary in size from a few yards to a half acre or more in extent. They were formerly made with the utmost care, by first removing the earth down to a water level and

PLATE 11. ETHNOGRAPHIC GROUPS IN THE BISHOP MUSEUM.

(Groups Assembled by the Author.)

(For description of Plate see Opposite Page.)

using the surplus soil to build strong embankments on all sides of the pond, which, when necessary, were re-enforced with stones, sugar-cane and cocoanut leaves. The earth in the pond was then carefully manipulated so that the bottom and sides could be beaten solid. In early times the hard end of a cocoanut leaf was used as a flail when it was necessary to pack the earth firmly to form the walls and bottom into a water-tight basin. When the pond was water-tight the earth was thoroughly spaded and worked over for a couple of feet in depth. The water was then let into the pond and the earth mixed and stamped with the feet until a thin muck was formed.

The next step was the planting of the new crop. The leaves cut off in a bunch just below the crown of the plant as the ripe roots are harvested, form the huli. The taro is usually propagated by planting the huli while still fresh, in rows eighteen inches to two feet apart. Water is let into the patch, after planting, so as to form a shallow pond and a fresh water supply is constantly kept running into the patch until the roots become mature, when they are ready for use.

The taro plants usually require from nine to fifteen months in which to ripen, but they will continue to grow and improve in quality for two years or more. The provident Hawaiian would therefore plant but a small area at a time with the result that the plants would not all be ready to harvest on the same date.

In addition to the common method of pond cultivation just described several other methods continue to be made use of in the planting and cultivation of taro, which vary more or less in detail. In regions where streams were not available and where other conditions were suitable, the land was cleared of weeds and large holes dug in which several plants were set. When necessary the soil was enriched with kukui leaves, ashes and fine earth. The crop, if carefully planted in this way, and tended faithfully, would yield abundant returns.

DESCRIPTION OF PLATE.

1. Kahuna pule anaana. It was the business of these sorcerers to procure the death of persons obnoxious to themselves, or the chiefs, or their clients, by means of prayers and religious rites. They secured the spittle or some intimate belonging of the person whom they wished to destroy and by means of certain rites, conjuring and prayers to the gods, so wrought upon the imagination and superstitious fear of the individual as to almost invariably bring about his death. At the left is shown a large cocoanut hula drum [pahu hula] that formerly was only beaten on the occasion of a royal birth. 2. Group designed to show the process of poi pounding. 3. Tapa making; the old woman is shown beating the bark on the wooden anvil [kua kuku] with a tapa club for the purpose of thinning the wet bark or felting the edges of the strips together. The girl stands by with an umeke of water to sprinkle on the bark from time to time; on the bush beside her are a number of strips roughed out ready to be beaten thin and smooth; behind her a finished sheet is in the process of being ornamented. 4. Scraping olona. The long fibers of this useful plant are hackled out by scraping the bark on a narrow board [laau kahi olona] with a tortoise shell scraper [uhi kahi olona kuahonu]. From the fiber, twine for all purposes, but especially useful in the manufacture of fish nets, was made. In the case behind are shown such fishing apparatus as seins, nets, fish hooks, shrimp baskets, sinkers and all the various articles made use of by the native fisherman.

Taro and Its Uses.

Several varieties of taro were planted by the natives which varied in size, flavor and growth. In general, however, the varieties all have large, thrifty, heart-shaped leaves of a light green color. The flower is a fragrant, green-yellow, calla-like blossom and inconspicuous. The root is of a regular oval form, from four to eight inches in length, and from two to four inches in diameter. In a natural state, when either ripe or unripe, both the root and the leaves have the exceedingly acrid, pungent taste so characteristic of the genus of plants to which the taro belongs. But when thoroughly cooked it becomes mild and palatable without a more disagreeable, peculiar or characteristic taste than spinach or potatoes might be said to have. When the root is ripe it is compact and whitish in color, both before and after cooking; but when poor in quality or unripe, it is liable to be a dull lead color. There are several varieties, as the pink or royal taro, and the blue, or common taro, which differ as indicated in the color of the ripe and cooked roots as well as in the color of the poi made from them.

The natives prepared the root for use, as they cook all their food, by first baking it in a curious oven called an imu. The oven is formed by digging a hole two or three feet in depth and six or more feet in circumference and placing in the bottom of the hole a layer of stones. On the stones wood is piled and on top of the heap still other layers of stones are laid. A fire is then lighted in the pile of wood and kindling. When the stones are thoroughly heated those on top are thrown to one side and the taro, sweet potatoes, bananas, pig, dog, fish or whatever is to be cooked is wrapped in ki or banana leaves and laid on the stones in the bottom of the hole. The loose hot stones are thrown in on top of the bundle of leaves containing the food, and a little water is added to create steam; the earth and leaves are then hurriedly placed on the mound to prevent the heat from escaping.

Poi.

The taro after being cooked in this manner was and is made into the favorite dish of the Hawaiians, namely poi. The process of manufacture, though simple, was laborious and was invariably performed by the men. The first step in the process of transforming taro into poi was the removing of the rough outer skin of the root after it had been thoroughly cooked. The scrapings thus secured were put aside to be returned to the ponds as a fertilizer. The roots when carefully scraped were thrown on a short plank of hard wood called a poi board. The board was scooped out slightly in the middle, like a shallow tray. On this plank the roots were pounded with a thick, heavy stone pestle, of which two or three forms were formerly in use.

Poi pounding is real work, and when it was to be done properly the natives stripped themselves of everything save their loin cloths. Seating themselves cross-legged, usually one at each end of the poi board, the pestling of the

mass would continue for an hour or more. With careful manipulation the roots were thus reduced to a sticky, dough-like mass. As the pounding proceeded, water was judiciously added to prevent the mass, in the form called paiai, from sticking to the stone pestle. When it was sufficiently smooth and firm it was removed from the board and at once made into poi by thinning with water to whatever consistency was desired; or made into good-sized bundles wrapped with ki leaves. In this way the paiai could be kept for months at a time and was often shipped from place to place. It was in this condition, in all probability, that taro formed one of the chief stores made use of by the natives in their long voyages.

Whenever poi was required a portion of the doughy mass, paiai, was put in a calabash and thinned with water. It was ready for use in a few hours after the water was added, but the natives preferred it after it had soured, or worked, for a day or more.

Poi was eaten by thrusting the forefinger of the right hand into the mass and securing as much as would adhere to the finger, and then passing the food from the bowl to the mouth by a neat revolving motion of the hand and finger. The native name for the forefinger signifies the "poi finger.' For this reason it was quite the custom to grade poi as one-finger poi, two-finger poi, and so on, thereby indicating its consistency. When ready to be eaten a dozen or more natives might surround one calabash and greedily dip up its contents, sucking their fingers and smacking their lips in a state of obvious enjoyment. Usually they finished the entire allowance at one sitting, only to fall asleep afterwards—"full and satisfied." Poi was occasionally mixed with the tender meat of the cocoanut, and was specially prepared for the sick in several ways. Baked taro also makes an excellent vegetable, and the leaves of the plant, as well as the stems and flowers were cooked and greatly relished by the natives.

Sweet Potatoes and Yams.

Next to the taro, sweet potatoes and yams were the most important food plants grown in the islands. Many varieties, accurately described and named by the natives, were in general cultivation. They thrived in the drier localities and were eaten raw, baked or roasted. They were also made into a kind of poi. Poi and sweet potatoes were fed to their pigs and dogs to fatten them, and animals cared for in this way were regarded as particularly delicious by the Hawaiians of a century ago.

Breadfruit and Bananas.

The breadfruit was much used as a food by the natives, after being cooked in their ovens or roasted in an open fire. It was pounded into a delicious poi as well. The natives were very skillful in growing this delicate plant, which was propagated by root cuttings. Bananas were also cultivated by them and eaten both raw and cooked. Sugar-cane, calabash gourds, the paper mulberry, olona, ki, cocoanuts and awa were among the useful plants formerly grown by the Hawaiians.

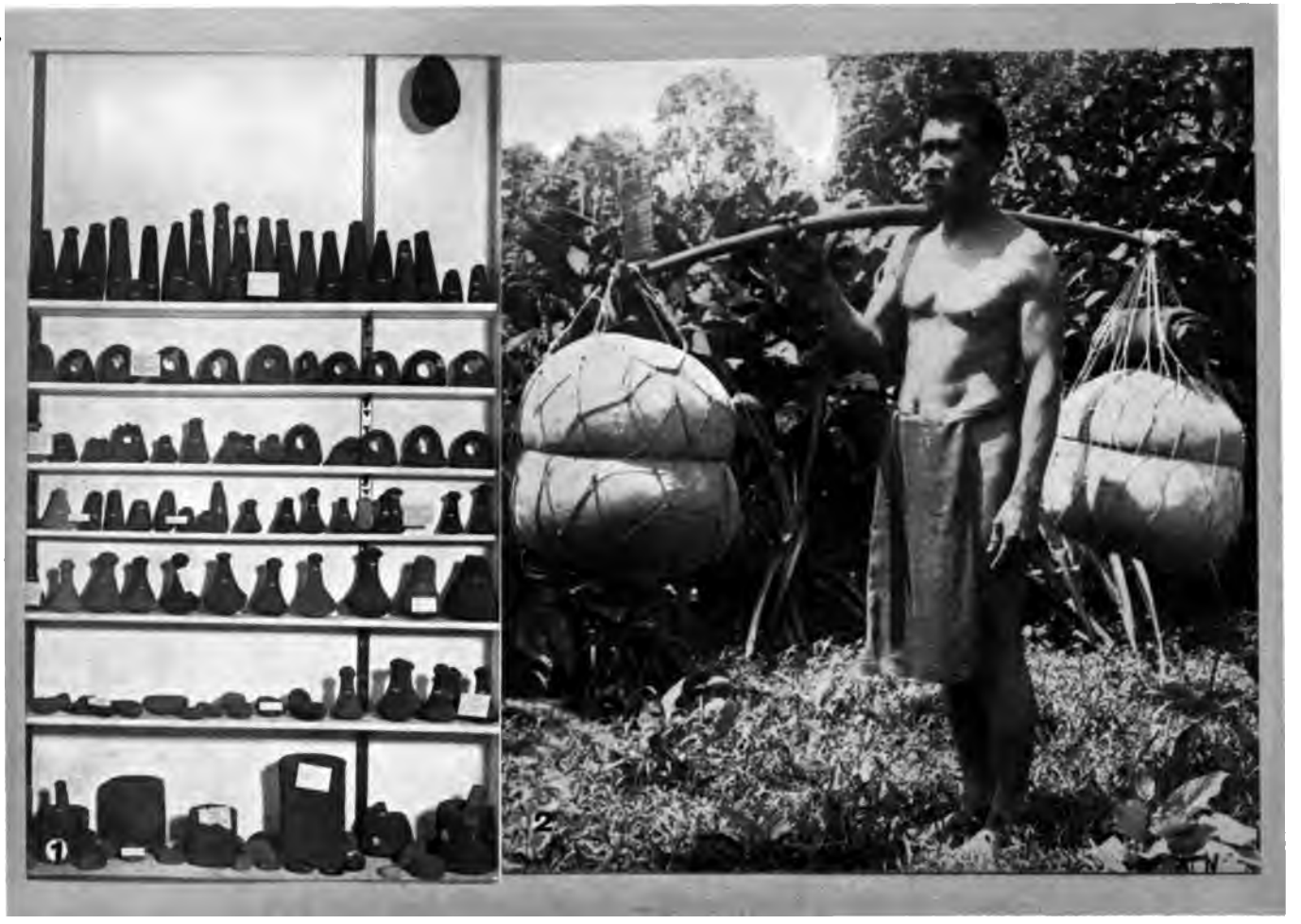

PLATE 12. STONE IMPLEMENTS AND CALABASHES.

1. A case of stone implements in the Bishop Museum showing pestles, poi pounders of various forms, stone cups, mortars, squid hook sinkers, and similar objects. 2. Hawaiian traveler carrying gourds containing food and clothing, suspended in the koko from the carrying stick [auamo].

In addition to the foregoing list of plants that were cultivated to a certain extent, there were a number of others that were made use of as food in times of scarcity that could hardly be regarded as cultivated in a strict sense.

Fiber Plants.

The paper mulberry, called wauki, one of the plants from which their bark cloth was manufactured, was regularly cultivated, there being extensive groves of this small tree planted about almost every native home. The plant was kept carefully trimmed from its earliest growth in order to prevent it following its inclination to branch out from the main stem. In this way a single shoot was secured unbroken by branches. When it had attained a height of ten or twelve feet and a diameter of an inch or two, the men cut the plants and the women stripped off the bark in a single piece by splitting it from end to end of the stem. The outer bark was then scraped off and the fibrous part forming the inner bark, was rolled endways into loose disk-like bundles and left to dry until it had taken on a flat surface. The bark was then placed in water until it became covered with a mucilaginous coating; then it was laid on a stone or a log prepared for the purpose and beaten with a series of round and square sticks of hard wood, known as tapa beaters.

Manufacture of Tapa.

In the making of tapa cloth, strips of raw material were laid side by side and doubled, pounded and manipulated in order to unite the free edges, the mass being kept saturated with water during the process. The length and breadth of the tapa sheet was increased at pleasure by the addition of more bark. Sheets double the size of an ordinary blanket were frequently made in this simple way. The water mark in the fibre, as well as the texture and thickness, was regulated by the amount of the beating and the character and markings of the mallet used. Places torn in making the sheet were mended by rewelding the edges. When finished the tapa was spread in the sun to dry and bleach.

The next step in the process was the dying and marking of the cloth. The tapa is naturally of a light color and much of it was worn in that state, but a great portion of it was stained either with dyes, mostly of vegetable origin, or by mixing with the sheet while in a plastic state fragments of old colored tapas that had been reduced to pulp. The colors used were both beautiful and durable—yellow, salmon, straw, blues in various shades, purple, green, red, lilac, pink, dove, chocolate, brown, fawn, as well as black and white were quite common. The list of vegetable and mineral dyes utilized to produce the various colors is a long one and shows a knowledge of the simple chemical reactions of the dyer's art that is truly remarkable. Leaves, roots and bark were used in various conditions, singly and in combination, often with mineral substances, as salt, earth, muck, charcoal, or occasionally with animal dyes, as that derived from the sea-urchin, the squid and certain sea slugs.

PLATE 13. OBJECTS OF NATIVE MANUFACTURE.

(Scale line—6 in.)

1. Large wooden idol of ohia wood, long buried in a fish pond. 2. A wooden image of Kalaipahoa, the poison god. 3. Hawaiian fish baskets and traps. 4. Canoe paddle.

(Description of Plate Continued on the Opposite Page.)

Tapa Making a Fine Art.

The plain or colored tapas were, often, beautifully and tastefully printed with ingenious figures or patterns of various designs. The pattern to be transferred to the cloth was first cut on the side of a narrow strip of bamboo. The bamboo was then dipped into the color and the pattern carefully printed on the tapa by pressing the stick on the tapa and against the hand. This operation was repeated until little by little the intended design was completed. Often the entire tapa was printed with various designs and colors in this primitive manner. Some kinds were marked with a string dipped in the color to be transferred. The string was then drawn taut across the tapa and the color snapped on it in the same manner in which the chalk line is commonly used.

In the preparation of their "printing inks" the colors were frequently mixed with kukui nut oil. Some tapas were saturated with cocoanut oil to render them waterproof and to make them more durable. Tapas which were not oiled could not be washed. For this reason the laundry work to be done in the Hawaiian family was reduced to the minimum, but the amount of time and labor expended in the manufacture of the tapa must have been enormous, since three or four days were required to beat an average sized tapa and a new set was required about once a month. Other materials were used by the Hawaiians in the manufacture of tapa, the most important being the bark of the mamake, which grew wild in the woods. It was gathered by the women and steamed in an oven with a certain fern that gave off a dark red coloring matter. The bark from tender breadfruit stems was sometimes used, as was also the bark from the hau tree.

Provision was commonly made for carrying on this work by providing a special house devoted to the purpose and also by the setting aside of certain special gods to preside over the undertaking. Certain of their tapas were delicately perfumed with the root of the kupaoa; maile and mokihana were also used in this way on account of their delicate and lasting scents.

It is worthy of remark that tapa beating was common among all the Polynesian islanders, when suitable material was to be had. It was an art that was old in the hands of the pioneer Hawaiians at the time of their settling on these islands. While tapa making was generally practiced over the whole of the Pacific, and indeed almost the whole world, it fell to the painstaking Hawaiian women to carry the manufacture of paper cloth to the highest degree of excellence attained among any primitive people. Their best tapas were but little, if any, inferior to the fine cotton fabrics that have entirely displaced

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(Description of Plate Continued from Opposite Page.)

5. Small kahili. 6. Slop bowl ornamented with human teeth. 7. Stone lamps of various forms. 8. Feather cape [ahuula]. 9. Tapa beater. 10. Poi pounders (ring form). 11. Pandanus baskets. 12. Finger bowls of various designs. 13. Spittoons. 14. Large and small umekes or bowls. 15. Hanai poepoe. 16. Carved dish for baked pig. 17. Gourd hula drums. 18. Hawaiian fans. 19. Cocoanut wood hula drums. 20. Uliuli hula or rattles. 21. Mortar and pestle.

them. So completely, however, has the art and manufacture disappeared that the implements used in its manufacture even are only to be seen in museums, while the technique of the art must be gleaned from the scanty records of the early missionaries and travelers.

Mat Making.

Perhaps the manufacture next in importance to the making of tapa was the plaiting of mats. These were used by the natives to lounge upon by day and to sleep upon by night. Mats were also used as sails for their canoes, as partitions in their houses, as food mats, clothing and robes,—in fact their uses were innumerable. Taken altogether, being more durable than tapa, their possession in abundance was regarded as unmistakable evidence of material wealth.

The typical bed of the Hawaiian chiefs was a raised portion of the floor, perhaps one entire end of the house. The elevated portion was made of loosely laid stones forming a pile eight or ten feet square, over which was spread several thicknesses of mats, as many as thirty or forty being employed on the bed of a well-to-do chief. Naturally the coarsest ones were placed at the bottom and the finer ones spread on top. Lauhala mats are still made and used quite generally throughout the group, many of the best houses being furnished with them in place of the more familiar though less approved floor rugs. Several materials were made use of in the weaving of mats, the most important being the lauhala; next came the stems of the makaloa, and lastly species of other native sedges.

Lauhala Mats.

In the making of lauhala mats, the leaves were broken from the trees, by the women, with long sticks. They were withered over a fire for a short time and then dried in the sun. The young leaves were preferred to the old ones, so that in plaiting the mats the raw material was carefully selected and graded as to quality and color. It was then scraped, the saw-like edges removed, and split into strips of the required width, varying from an eighth to an inch or more in width. The braiding was done by hand without the aid of a frame or instrument, and, though mats were often made twenty-five feet square, they were finished with great evenness of texture and regularity of shape. The finer braided ones were usually small in size and left with a wide fringe; being greatly prized, they were occasionally carried by attendants to be spread down on other coarser mats when their chiefs chose to sit.

Makaloa Mats.

The rush or sedge mats, called makaloa mats, are soft and fine; the islands of Kauai, and particularly Niihau, were famous for their production. For this reason the mats are frequently spoken of as Niihau mats. But on both islands the finest mats were those made from the young shoots.

Many of the lauhala, as well as most of the Niihau mats were ornamented with

much taste—red and brown sedge stems being used for the purpose. These were worked in on the upper surface of the mat in patterns that resembled embroidery, various designs being formed, as squares, diamonds, stripes and zigzag lines.

The plaiting of mats, like the beating of tapa, was women's work in ancient Hawaii, and those who possessed much skill in these important arts were esteemed for their labor and praised for their handiwork.

Fishing.

Aside from war, fishing and agriculture were the chief occupations engaged in by the men, so that, in general, men procured the food while the women did their full share in making the provisions for the Hawaiian family, and supplying the raiment that their civilization required.

Fishing, like agriculture, was associated with religious ceremonies and the worship of idols. Among this class, the practice was carried to such an extent that special heiaus and altars were constructed and a somewhat different form of worship established. Like the fishermen in all lands and in all times, the natives were firm believers in good luck and their faith in signs and omens was accordingly deep-seated. Their gods were numerous, so that each fisherman worshipped one of his own choice. Likewise the tabus of their gods were many and the devotee would go to a great length in carrying out the fancied desire of his patron deity. The god of one fisherman would tabu black, for example, and in observance of the tabu, the fisherman would have nothing black on his net or canoe, would take nothing black from the seas, and his dutiful wife would wear nothing black upon her person nor allow the tabu color to appear even in the vicinity of her home.

The business of fishing was carried on with great skill and those engaged in the occupation had an extensive knowledge of the habits, feeding grounds and species of fish in the sea round about the islands.

Fish nets were made in various forms for various purposes. They were netted of a twine manufactured by twisting the fiber of the olona to form cordage, most remarkable for its durability. As a substitute in certain cases, cord made from the cocoanut fiber was used, though it was by no means as flexible or durable as the former. The olona grew in a semi-cultivated state, in the mountain valleys, where abundant rainfall was assured. The bark was gathered from the young shoots, which were stripped and hackled with a scraper made of tortoise shell or bone.

Nets of various sizes and patterns were designed for various purposes, as were various fish hooks, poisons, traps and the like. A few of these will a fuller treatment in a chapter devoted to Hawaiian fish and fishing.

Salt Manufacture.

Salt was an important article among the Hawaiians and they were adept in the manufacture of a coarse salt from the sea water. Two methods were employed: One, that of putting the water in shallow scooped-out stone dishes

to evaporate; the other, by impounding the sea water in small shallow ponds and collecting the residue as the water evaporated. Salt Lake, on Oahu, also was an important source of supply.

The foregoing were the principal productive occupations that consumed the four to six hours a day that the ancient Hawaiians devoted to labor. It is, however, not to be presumed that these were the only pursuits in which they could engage. Certain districts and settlements became famous for their peculiar wares and products. Occasional fairs or markets were held at which the products and articles of manufacture of one district were exchanged for those of another, and a crude sort of barter was thus in vogue by which, recognizing the importance of specialized skill, or by utilizing special natural advantages, the wants and necessities were supplied, so that food, clothing, ornaments, utensils and tools might be had by all.

CHAPTER VII.

TOOLS, IMPLEMENTS, ARTS AND AMUSEMENTS OF THE HAWAIIANS.

The Hawaiians at the time of their discovery by white men were still in the stone age. The absence of iron, copper or any of the metals in a workable form was a serious handicap to their development. Stone, bone and wood were the materials at their disposal, and from them they were forced to construct such tools as they could devise.

Implements of Stone, Bone and Shell.

Of the simpler tools made use of by the natives, none was of more value and importance than was the stone adz. It was formerly in general use throughout the whole group, as it was throughout the most of Polynesia. In Hawaii adzes were made in various shapes, weights and sizes, for various purposes, but the principle was the same in all and consisted in the securing of a cutting or bruising edge of stone that might be held in a convenient form for use as a hand tool.

The hardest, most compact clinkstone lava was selected for the bit by the ancient adz maker. The rough stone was patiently worked into form by chipping, splitting and grinding. When at last the proper shape was secured, the bit was bound to the handle, (usually made from a branch of the hau tree), by means of a cord made of cocoanut or olona fiber.

In certain cases, the bit was used without the addition of a handle. For heavy work, as the felling of trees, the shaping of canoes, or the framing of the house timbers, large adzes were required, and there are some in existence that weigh several pounds. For more exacting work, as in carving their hideous idols, or finishing and mending the umekes, fine chisels were needed, and examples are extant that are, in effect, carving sets in which simple forms of

gouges, chisels, and the like can easily be recognized. Among their implements they had sharpening stones made of hard phonolite, which were used to give an edge to their tools, or as polishing stones. Some of these were boulders and were permanently located, while others were smaller and could be taken about as rquired. The saw-like teeth of the shark were used as tools in many ways, where cutting, scraping, and sawing edges were required. One of the most curious of their tools was the rotary or pump drill. The staff, tipped with a slender piece of hard lava or a Terebra shell, was fitted with a crude fly-wheel and a bow-like device, which caused it to spin back and forth. This simple device was convenient for boring the innumerable holes required to accommodate the cord that, for want of nails, was used in fastening all kinds of objects together. Hand stones for hammers, stone files for making fish hooks of bone, scrapers of bone and shell, stones for smoothing, fine pumice, coral grit and other fine materials for polishing, were all tools commonly found in an artisan's kit. The oo or digger, a long staff of hard wood, was almost the only tool of husbandry, while in net manufacture the simple and widely used seine needle and mesh gage were practically the only tools employed.

As we think of the endless variety of tools necessary to perform even the most ordinary task in our own more complex civilization, it seems incredible that the patient Hawaiian, with such exceedingly simple tools at his command, could have utilized the materials of his environment to such splendid purpose. The wonder of their achievement grows when we contemplate not only the variety and amount of their handicraft, but the neat and substantial character of their work—a trait for which the ancient Hawaiians are justly famed.

Ornaments of Feathers.

Ornaments wrought from the feathers of birds were among their most valuable possessions. Among their handicraft, especially such as had to do with adornment, nothing made by them surpassed in elegance their feather capes, helmets, cloaks, leis, kahilis, and feather pa'us or dresses. So handsome were they that their possession was almost entirely limited to the alii or persons of rank, or those of special distinction.

The most valuable of all were the feather cloaks or robes of state, which were indeed priceless insignia of rank. The most valuable were made entirely of the rich, golden-yellow feathers of the very rare and now extinct native mamo. A robe in the Bishop Museum that was the property of Kamehameha I, is composed almost entirely of the feathers of the mamo, and constitutes one of the Museum's chief treasures. As the arrangement of the cloak was always such that additions could be made from time to time, it is not to be wondered that this beautiful robe of state, which occupied over one hundred years[1] in making, should be valued at as high a figure as a million dollars, when the amount of labor involved in the gathering of the raw material from which it was made is taken into account. As a substitute for the rarer golden-yellow mamo feathers, certain more common yellow feathers from the now

[1] Nine generations.

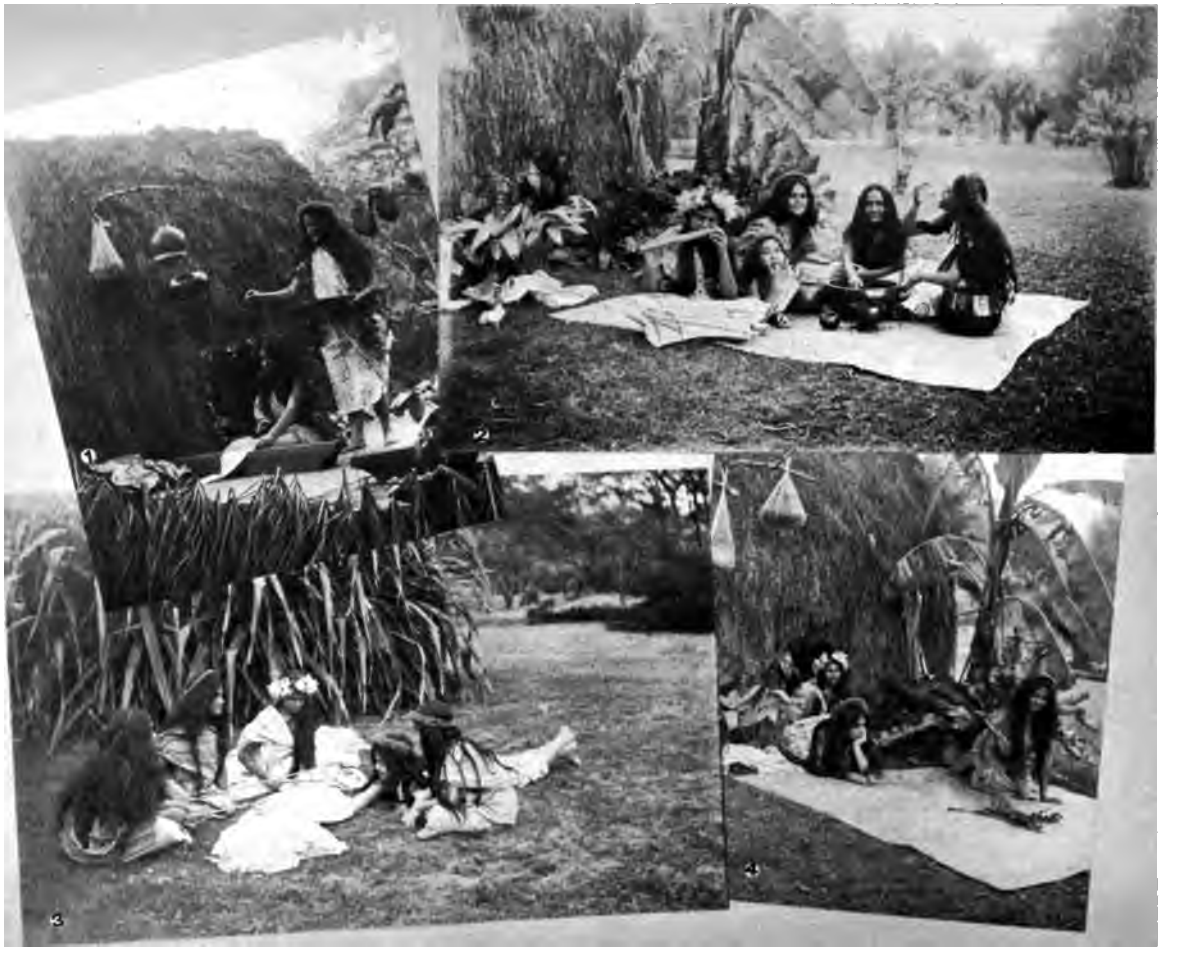

PLATE 14. HAWAIIAN GIRLS AT WORK AND PLAY.

1. Tapa making. 2. Eating poi and playing the nose flute. 3. Playing Puhenehene—a guessing game. 4. Sweeping a mat with a broom made of cocoanut leaf ribs.

equally rare oo were used by the old Hawaiians. The feathers of other birds as the iiwi, apapane, ou, koae and iwa were used in combination with the foregoing or in various other ways, in the different articles mentioned, that chiefs and those who could afford them might have capes; but the yellow feathers were reserved for royalty only. The ground work for the capes and cloaks was a fine netting made of the native olona; to this the feathers were firmly fastened in such a way as to overlap each other and form a smooth and uniform surface.

The Kahili.

The kahili, a fly brush or plumed staff of state, was the emblem and embellishment of royalty and was held in the time of which we write, solely as an adjunct of the alii. A few of these curious feather plumes were of enormous proportions, there being records of some that were borne on poles thirty feet in length. The plume was composed of feathers arranged in bunches, bound on stems, which were attached to the central staff in such a way as to form a loose, fluffy, cylinder-shaped head, sometimes two or more feet in diameter by three or four feet in length. The handle was occasionally made of alternate rings of ivory and tortoise shell. In some instances the bones of the famous alii slain in battle were placed on the stem as trophies of victory or as savage ornaments. However, the kahili handle was commonly made of a stout spear-like shaft of kauila wood. Many of the smaller kahilis were definitey used for the purpose of fly flaps and are thought to be the form from which the larger and more ornamental ones were evolved.

Their helmets, which were exceedingly picturesque and striking ornaments, were generally worn by the chiefs on state occasions. They were made of wicker work of the aërial ieie roots, covered with the feathers of several species of the birds mentioned, red and yellow being chiefly used, and were extremely variable in form.

Hideous effigies of the powerful war god Kukailimoku[2] were made of wicker work and feathers, like the helmets, and were usually supplied with staring pearl-shell eyes and horrible grinning mouths set round with dogs' teeth. We are told that not more than a dozen of these curious feather gods have been preserved in various museum collections.

Leis.

The feather lei was the simplest form of feather work wrought by the Hawaiians, and may be regarded as the royal counterpart of the more common and perishable garlands made of flowers, nuts and seeds. The flower and feather leis were twined through the hair or slung gracefully around the necks of both sexes, and seem to have had but little real significance other than to gratify a taste for ornament. Durable leis were also made of such objects as sea and land shells, boars' tusks and dried fruits.

An ornament much worn by the chiefesses was a necklace that consisted of

[2] Ku=a god; kailimoku=to-take-the-island.

PLATE 15. HULA DANCERS.

1. Hula girl with ki leaf skirt and anklets. 2. Hula girl wearing lauhala leaf skirt; an ilima lei is on the head, a maile lei about the shoulders, an ukulele (a modern instrument) is held in the hands. 3. Six hula dancers as seen on the occasion of the coronation celebration of King Kalakaua. 4. Six hula musicians with gourd drums [ipu hula].

many strands of finely braided human hair on which was suspended, as a pendant, a much-prized ornament, the palaoa, made from the tooth of a whale or walrus. These were tabu to all below the rank of chief. Necklaces of ivory beads were also prized; bracelets of shells, especially the pipipi, and of whale ivory, were worn, fastened on the back of the wrist with a small cord of olona. Boars' teeth were also used as bracelets. A beautiful amber tone was given to many of the ivory ornaments by wrapping them in ki leaves and exposing them for considerable time in the heavy, strong smoke of sugar-cane.

Medicine of the Hawaiians.

Of the practice of medicine and the use of medicinal herbs among the ancient Hawaiians, but little is known further than that it was a matter of worship rather than the practice of a healing art. It seems that superstition was the principal element combined with vegetable substances and crude surgery. The doctors were a distinct class of priests who worshipped certain gods from whom they were supposed to have inherited their knowledge of medicine. They were regular in the practice of their art in that they exacted offerings for the god of medicine before they would undertake a cure, and then forbade certain articles of food to the sick. As a matter of fact they seem to have had considerable knowledge of the medicinal properties of herbs though they were by no means uniformly successful in their prescription and use. They followed a crude form of external diagnosis for internal ailments. They were adept in the use of rubbing and manipulation to alleviate soreness and minor ills. They set limbs with some skill, reduced inflammation by the use of herb poultices and made use of the pulp of the calabash gourd vine as a cathartic. Patients were held over the smoke of specially prepared fires for certain ailments, were steamed over hot stones for others, and so on through a long list of practices that were, no doubt, useful in securing to the patients the satisfaction of feeling that they were at least doing something for their ailments. From the natural history point of view their practice of medicine adds much interest to the study of the botany of the islands, for a surprisingly large number of native plants were well known as specifics for different diseases, and to this day frequent allusions are made by the natives to the uses of various plants by the old kahuna doctors.

Implements of Warfare.

Although war was an important vocation with the ancient Hawaiians, there being a certain period of the year set apart during which it might properly be engaged in, the implements were few and simple. They consisted chiefly of spears, javelins, daggers and clubs made of tough wood and were, as a rule, smoothly polished. They had no armor other than the gourd masks worn by the canoe men. The Hawaiian warriors preferred to fight dressed in their malos only. As a substitute for the shield, a device of which they ap-

PLATE 16. THE SURF-RIDERS.

(For Description of Plate See Opposite Page.)

peared to be ignorant, they used their stout spears in warding off blows. These were made of heavy solid wood perfectly straight in form and were twelve to twenty feet in length. Their javelins were smaller, being about six feet in length and were provided with plain, arrow-shaped, or barbed heads which, though dull, were effective when thrust against the bare skin of the enemy. The next most important of their weapons were stout clubs of various sizes and forms made of wood, stone or bone. With these they were able to deal a powerful blow. Their dagger-like sword was from sixteen inches to two feet in length and was frequently pointed at both ends. This weapon was supplied with a string of olona by which it was suspended from the wrist. Another form of sword had a saw-like edge set with a few shark teeth. The bow and arrow in a diminutive form, although used by the alii in the royal sport of shooting rats and mice, was never made use of in warfare; instead, slings manufactured of human hair, braided pandanus or cocoanut cord were the important weapons of defense. With them they were able to hurl the smooth egg-shaped pebbles which they prepared with special care, with great force and accuracy. The canoe breaker, made for naval warfare, was simply a round stone firmly fastened to the end of a rope. This could be whirled about the head and thrown with sufficient force to smash the thin shell of the enemy's canoe.

The instruments made use of in hand-to-hand encounters were knives fitted with one or two shark's teeth; disemboweling weapons were made by fastening a single shark tooth firmly in a short stick of wood, so arranged as to be carried concealed in the hand, until, in an unguarded moment, it could suddenly be made use of with fatal effect. A rarer weapon, used in securing victims for human sacrifice, was a stout cord in a slip-noose form, that was firmly fastened to a knob-like handle. In use the noose was stealthily thrown over the head of the intended victim and hauled taut from the rear by the knob, the back of the victim usually being broken in the attack that followed.

While the natives were industrious and skilled in the pursuits of peace, expert in their primitive arts of war, and an exceedingly religious people, they found much time for amusements and devised many games suited to both children and adults, from which they derived much enjoyment.

The Hula.

The hula was the form of diversion most commonly indulged in. All of every age and character took part in it. It was not so much a dance in the usual sense of the term, as a form of religious service in which acting in gesture and movement was made use of in developing the ideas expressed by the song

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Description of Plate.

1. Hawaiian youth standing on the surf board [papa hee nalu]. 2. Showing the shape and size of the board. 3. Racing in the surf at Waikiki; Diamond Head in the background. 4. An outrigger canoe (waa) showing the outrigger (ama) of wiliwili wood and the connecting bars [iako] of hau and the gunwale [moo] of ulu. The paddles [hoe] are of koa and kauila wood. 5. Two single canoes on the beach. The hull of the canoe is always made of a single koa log.

which the gestures accompanied. Like everything else the Hawaiians did it was made the subject of extensive religious ceremonies and was accompanied by an intricate form of worship in which Laka was the chief goddess. Naturally there were many forms of the hula, some of them extremely lewd. The latter class, unfortunately, have been used more than any other single thing to spread the fame and infamy of Hawaii, and create an erroneous and distorted impression of the Hawaiian race. Yet it should be understood that their dances were, in the main, entirely chaste; but, unfortunately, some of them were intended for the gratification of the baser instincts and it is these, under the encouragement given by a certain class belonging to our own European civilization, that are most frequently seen in our own times.

The dancers, who were usually though not always women, wore the pa'u, or hula skirt, about their waists, with wreaths of flowers about their heads and shoulders. Occasionally dogs' teeth anklets, hogs' teeth bracelets and whales' teeth ornaments were worn by the participants. The performers stood or sat singly, or in companies, according to the hula being given, usually staying in one place and moving their body and limbs in perfect time and in keeping with the sentiment of the accompanying chant, which was accentuated with the various sounds produced by a series of primitive musical instruments. It is a curious fact that almost all the Hawaiian musical instruments were made use of in the performance of the hula. Naturally the most important instruments were those calculated to mark the crude intervals of time in their chanted songs. The large drums, some of them three feet in height, with half that diameter, made of hollow cocoanut stems over which shark skin heads were stretched, were played by rapping with the finger tips and were especially prized. Other drum-like instruments, with astonishing resonance, were made from large bottle gourds, two of which were joined by inserting the neck of one within the other.

Musical Instruments.

To produce the sound desired, the gourd instrument, held in the hand by a loop, was dropped on the padded floor of the house and at the same time beaten with the palm of the hand, thus varying the sound to accord with the action and feeling of the accompanying song. The deep base of the larger drums was supplemented by the rattle of lesser drums made from cocoanut shells with shark skin heads, or by rattles of small gourds partly filled with dry seeds. Other rattle instruments were made by splitting a long joint of bamboo for half its length, to form small slivers, so that the free ends, in response to the lively motion from the hands of the player, produced a curious swishing sound. A still more primitive instrument was made of two sticks of hard, resonant wood which were struck together.

The most ambitious musical instrument of the ancient Hawaiians and one requiring unquestioned skill in its manipulation, was the nose flute. To make the nose flute, a long, single joint of bamboo was used. One end was left closed by the joint and three small holes bored along the upper side, one near the

closed end, the other two about a third of the distance from either end. In playing, the instrument was held so that the end hole was squarely under the right nostril. The sound produced was modified by the finger holes to give five notes, which might be varied at the pleasure of the performer.

A similar instrument was the love-whistle or kiokio, made of very small gourds in which three holes were pierced. The method of playing this tiny instrument was similar to that of the nose flute. Another instrument sometimes used to accompany the mele, was based on the principle of the Jew's harp. It was made of a short stick of bamboo slightly bent in such a manner as to hold the three strings of olona fiber taut. In use one end of the instrument was placed in the open mouth which served as a resonator for the feeble tones produced by striking the strings with the fingers or with a bamboo splinter as a plectrum.

Boxing the National Game.

Returning to their festivals and games, for there were many in which strength, skill and chance played an important part, we find boxing was, perhaps, the national game. It was regulated by certain rules, umpires were appointed, the victor defended the ring against all comers, the conqueror receiving the highest honors. A great crowd of all classes usually attended their games and sports, and wild excitement and much hilarity prevailed. In many of the important contests between the followers of various chiefs, not infrequently death was the result of blows received.

Wrestling and foot racing were also popular sports. It is recorded that the king's heralds were frequently able to make the circuit of Hawaii, a distance of three hundred miles, over exceedingly rough trails, in eight or nine days.

A game which must have contributed much to their skill as warriors, in their form of warfare, was one in which spears were thrown a short distance at the body of the contestant—to be parried by him. The more skillful, it is said, were able to ward off a number of spears at once. Mock fights with stones, spears and other missiles, were also indulged in.

The Primitive Bowling Alley.

A favorite amusement was one which consisted in bowling or rolling a smooth disk-like stone over a track especially prepared for the purpose, with sufficient skill to cause the stone to pass between two sticks driven a few inches apart at the opposite end of what may be termed a primitive bowling alley. The game had many variations, one being to excel in bowling the longest distance. Still another modification of this game had as its object the breaking of the opponent's bowling stone. Amusements of precision, like the above, led to great care being exercised in the selecting of the material and the employment of much skill in the manufacture of their ulu or olohu stones. The best were preferably perfect disks in shape, of hard lava stone, or coral rock, and were three or four inches in diameter by an inch or more in thickness, with an average weight of about one pound. They were slightly thicker in the center, gradually

PLATE 17. MISCELLANEOUS HAWAIIAN PICTURES.

(For Description of Plate See Opposite Page.)

thinning slightly toward the edge of the stone. While this was the usual form, others that were perfect spheres are in existence that measure over seven inches in diameter and weigh as much as twenty-two pounds.

A sport which was justly popular with all classes was what might be called "summer tobogganing." It consisted in sliding down hill over carefully prepared slides, a few yards in width, on a long, double-runner sled. There are a number of these slides that are still pointed out as favorite coasting places of ancient times. Any smooth mountain slope of sufficient steepness would serve the purpose. The only complete sled in existence is in the Bishop Museum. The two runners of this one are each just over eleven feet in length and are three inches apart. They are firmly fastened to the narrow frame. The native tobogganer would lie flat upon this curious sled, the papa holua, and give it a push with his foot, to start it off. During the decent it would frequently gain an immense velocity, and the sport, while exhilarating, must have been accompanied with great danger to life and limb. Several of the old slides are more than a half mile in length, one on the town side of Diamond Head ran far out on the plain, and another still longer one is to be seen from King street, at the opposite end of the city of Honolulu.

Gambling.

Many of their sports and games were more properly games of chance. Gambling in various forms was indulged in by all classes in the natural state of their civilization. Seldom did they enter into serious contests without an accompanying bet of some sort, so that food, clothing, ornaments, crops, wives, their daughters, and even the bones of their bodies after death, were wagered on the outcome of some simple contest.

In addition to those already described, cock fighting was also much affected in the ancient times, and was a game of chance of rare interest. They also played a game resembling checkers on a flat lava stone, divided into numerous holes or squares, using black and white stones for the men.

Surf Riding.

A favorite game in which women engaged with much skill, consisted in hiding a pebble, the noa, which was held in the hand, under one of five piles of tapa. It was for the opposing side to guess in which pile the stone was left, striking the pile selected with a rod tipped with feathers. There were also many children's games, such as flying kites, cat's cradle and jumping the rope. But the sports par excellence in which the chiefs and common people, both old and young indulged, were those which had to do with the wonderful surf for which

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Description of Plate.

1. Hawaiian girls plaiting lauhala mats. 2. Spear practice (from an old drawing). 3. Sheet of copper formerly affixed to a cocoanut tree at Kealakekua Bay marking the spot where Captain Cook met his death February 14, 1779. 4. Captain Cook's monument at Kealakekua Bay. This monument was erected by the British Government about fifty years after the death of the great explorer at a spot as near as possible to the place where he fell when killed by the natives. 5. Two old Hawaiians at home.

the islands are far-famed. Being excellent swimmers from their youth the natives were as a race devoid of fear. They would leap from high precipices into the foaming surf below, fifty, sixty and seventy feet; and it is still common to see the swimmers and divers in the harbor leap one after another from the bridge or from the life boats of the largest ocean steamers. But riding the surf with the surfboard was and is still the favorite amusement, and an art in which the Hawaiians always exhibited wonderful skill and dexterity. For this amusement a plank, preferably of koa wood, known as a surfboard, was used. It was a coffin-shaped plank averaging about ten feet in length by a foot and a half in width, though they were occasionally eighteen feet or more in length, and from that ranged down to very small ones for children. Some were made of the very light wiliwili wood. They were always made with great care and were kept smoothly polished. The swimmer, with his board, would gradually work his way out through the shallow water, over the fringing coral reef to where the high rollers rise over the outer reef and follow each other in rapid succession over the table-like reef toward the shore. The more terrific the surf, the greater the pleasure to those skilled in the sport, a form of recreation that is enjoyed in these modern and more strenuous times by natives and foreigners alike.

Selecting the proper kind of wave, the surf-rider would get his board under way by paddling furiously with his hands and feet. At the proper moment, mounting a high wave he throws himself on the board just as it is seized by the force of the on-rushing water. Skillful manipulation is required to manage and keep the board just abreast of the crest of the towering wave, which, if everything goes as planned, carries the swimmer and his board, at race-horse speed, clear into the shallow water at the beach.

In this manner they disported themselves for hours at a time, returning again and again, often standing erect and gracefully poised on their boards as they were wafted in on the bosom of the foam-capped wave. Surf-riding extended to canoe racing in which the principle just indicated was even more elaborately applied.

Strong crews of picked men would man their best type of racing canoes and pull out to where the surf began to rush over the reef. There amid the rush and dash of the sea, each crew would await the signal, when the race would begin, each man paddling furiously, until the canoes were caught by the waves, and amid wild shouts of exhilaration, scarcely audible above the ocean's roar, the successful crew would reach the shore, claiming the race, to the unbounded joy of all.

Thus we have hastily passed in review, the life, the customs and the culture of this splendid, though vanishing race. We have seen how, though isolated as they were from their own kind, they developed a natural civilization well adapted to their needs and their peculiar environment. We can now approach the natural history of the animals and plants, and the land itself, with a better

understanding of its meaning to the natives and a livelier appreciation of otherwise unimportant elements which have long been determining factors in the lives of these people.

We can now better understand the changes and modifications which have been wrought on the whole by the introduction of another race that has transplanted hither the animals, the plants, the industries and the arts of a more aggressive and far different civilization.

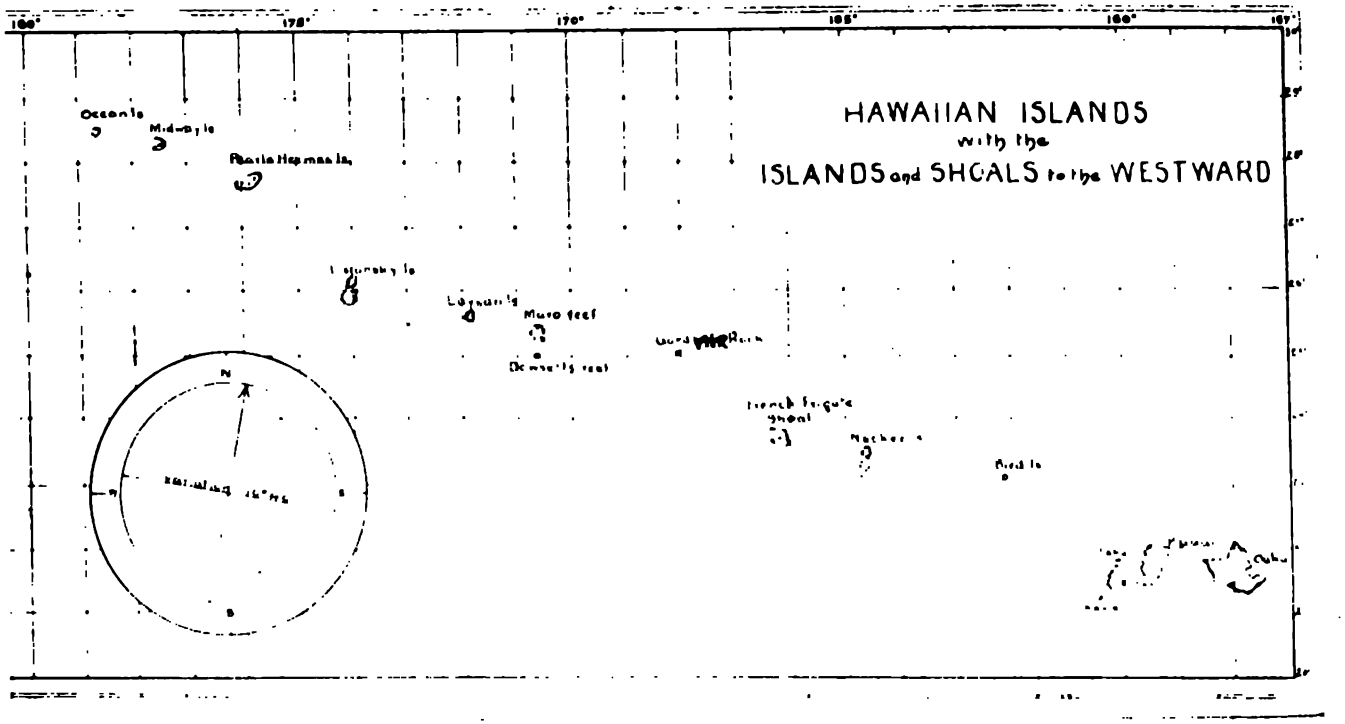

PLATE 18. MAP OF THE LEEWARD CHAIN OF ISLANDS OF THE HAWAIIAN ARCHIPELAGO.

Natural History of Hawaii.

SECTION TWO

GEOLOGY, GEOGRAPHY AND TOPOGRAPHY OF THE HAWAIIAN ISLANDS.

CHAPTER VIII.

COMING OF PELE AND AN ACCOUNT OF THE LOW ISLANDS OF THE GROUP.

Pele's Journey to Hawaii.

There is perhaps no better way to begin an account of the natural history of the Hawaiian Islands than by recounting an Hawaiian legend that tells of the coming of Pele, that powerful mythical deity of fire and flood, feared and respected by all the ancient inhabitants of the group as the source, as well as the end, of all the wonderful volcanic phenomena with which they were familiar.

In the beginning, so one version of the legend runs, long, long ago, before things were as they now are, there was born a most wonderful child called Pele. Hapakuela was the land of her birth, a far distant land out on the edge of the sky—away, ever so far away to the southwest. There she lived with her parents and her brothers and sisters, as a happy child, until she had grown to womanhood, when she fell in love and was married. But ere long her husband grew neglectful of her and her charms, and at length was enticed away from her and from their island home. After a dreary period of longing and waiting for her lover, Pele determined to set out on the perilous and uncertain journey in quest of him.

When the time came for the journey her parents, who must have been very remarkable people indeed, made her a gift of the sea to bear her canoes upon. We are told that among other wonderful gifts Pele had power to pour forth the sea from her forehead as she went. So, when all was in readiness, she and her brothers set forth together, singing, making songs, and sailing—on, on, on over the new-made sea—out over the great unknown in the direction of what we now know as the Hawaiian Islands.

But in the time of which the legend tells the islands of Hawaii were not islands at all, but were a group of vast unwatered mountains standing on a great plain that has since become the ocean's floor. There was not even fresh water on these mountains until Pele brought it. But as she journeyed in search of her husband, the waters of the sea preceded her, covering over the bed of the ocean. It rose before her until only the tops of the highest moun-

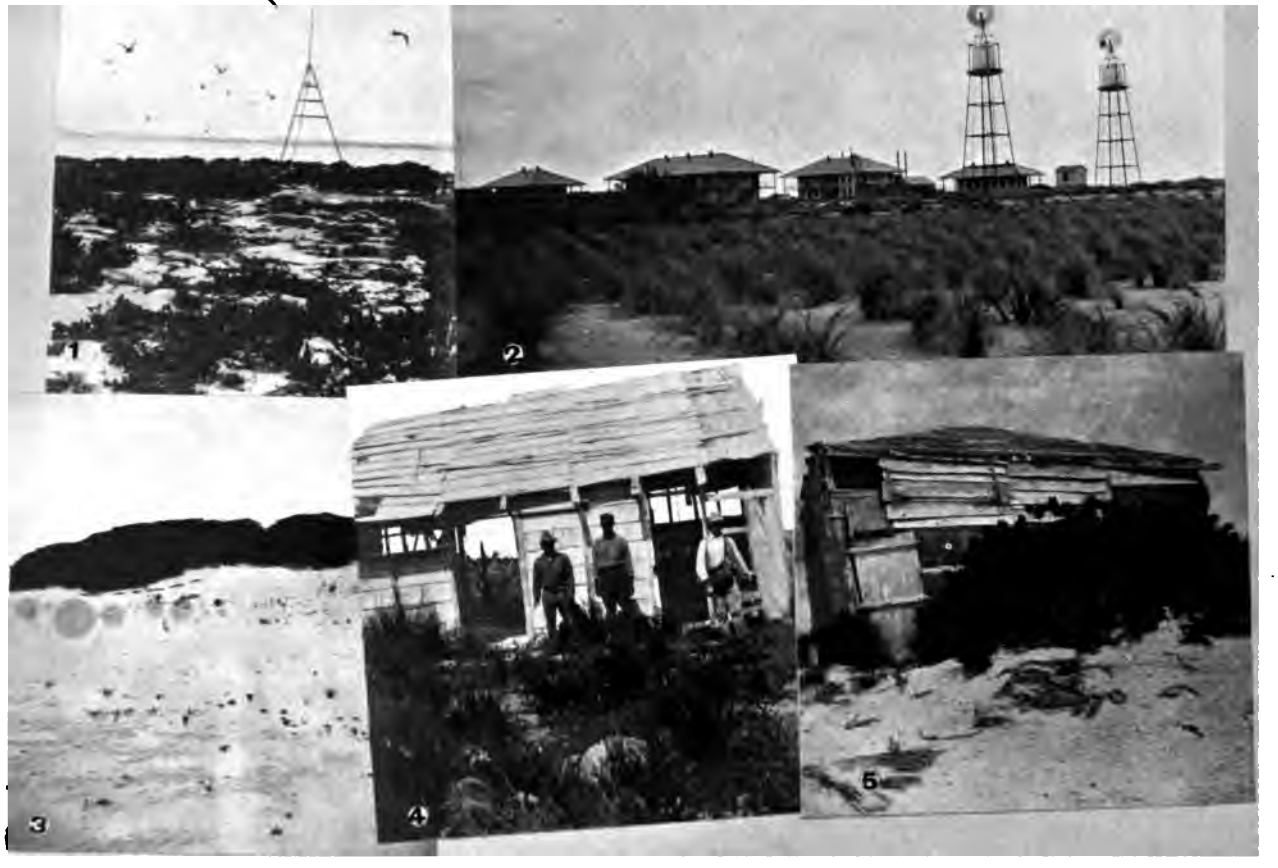

PLATE 19. VIEWS ON MIDWAY AND OCEAN ISLANDS.

(For description of Plate see Opposite Page.)

tains were visible; all else was covered by the mighty deluge. As time went on, the water receded to the present level, and thus it was that the sea was brought to Hawaii-nei.[1]

From her coming until now, Pele has continued to dwell in the Hawaiian Islands. According to the legend, her home was first on Kauai—one of the northern islands of the group. From there she moved to Molokai and settled in the crater Kauhako. Later she removed to Maui and established herself in the crater hill of Puulaina, near Lahaina. After a time she moved again to Haleakala, where she hollowed out that mighty crater. Finally, as a last resort, she settled in the great crater of Kilauea, on Hawaii, where she has even since made her abode.

In this way Pele came to be the presiding goddess of Kilauea and to rule over its fiery flood, and from those ancient days to the present, she has been respected as the ranking goddess of all volcanoes, with power at her command to lift islands from the sea, to rend towering mountain peaks, to make the very earth tremble at her command, to obscure the sun with stifling smoke, to cause rivers of molten rock to flow down the mountains like water, and above all to keep the fires forever burning in her subterranean abode.

This interesting legend should be regarded as a sincere effort of the Hawaiian mind to account for the presence in the islands of the primeval power they saw in the volcano and to explain certain fundamental phenomena of nature which surrounded them on every hand. Here were the islands, here were the burning mountains, here was the great sea, here were the people, the animals and the plants. Whence came they all, and how did they come to be?

Legend and Science Agree.

With all our boasted science, we are still groping, as were the ancient Hawaiians, seeking an explanation of the beginning of the islands, and of the marvelous variety of life which they support. In the search, science has substituted theory for legend, and observation for myth, but when we compare the legendary course of Pele as she moved her home, from the oldest island, Kauai, to the young island, Hawaii, with the theory that geologists have worked out to account for certain basic facts in the evolution of the group, we are surprised to find that legend so closely accords with the modern accepted theory of the succession in time of the extinction of the volcanic fires that marked the completion of one island after another, until Hawaii alone can boast of the possession of the eternal fires.

[1] All Hawaii.

Description of Plate.

1. Midway Island; looking from sand islet towards green islet, showing the characteristic vegetation. 2. Showing the cable station on Midway Island. Note the growth of sand grass (*Cynodon dactylon*) in the foreground. 3. View on Ocean Island showing the formation of sand hills under the protection of the low bushes (*Scævola Koenigii*). 4. Hut built on green islet by Japanese bird poachers. 5. Midway Island home of Capt. Walker and family, who were shipwrecked on the island in 1887 and spent fourteen months there before being rescued. (The hut has since been burned).

PLATE 20. VIEWS ON LAYSAN ISLAND.

1. Shows the sea breaking along the rocky ledge at the southeast point. 2. The lighthouse and manager's quarters showing two cocoanut trees brought from Strong's Island. 3. Laysan Albatross (*Diomedea immutabilis*). 4. Loading guano in a large schooner. 5. A lighter load of guano. 6. General view of the settlement on the "harbor" (west) side of the island.

Geographic Position of the Islands.

Considering the Hawaiian Islands in relation to each other and to the rest of the world, we find this wonderful group of mid-Pacific islands to be made up of twenty-one islands and a number of other small islets that are contiguous to the shores of the larger ones. For the sake of convenience, the group, which stretches for about 2,000 miles from southeast to northwest, has been divided into the leeward or northwest, and the windward or inhabited chain. In the leeward islands are grouped eight low coral islands and reefs, and five of the lowest of the high islands. Beginning at the western extremity, the low group includes Ocean Island, ten feet high; Midway Island, fifty-seven feet high; Gambier Shoal, Pearl and Hermes Reef, Lisiansky Island, fifty feet high; Laysan Island, forty feet high, and Maro and Dowsett Reefs.

These are probably the tops of submerged mountains that have had their summits brought up to or above the surface of the ocean by the combined action of the hardy reef-building corals, the waves, and the transporting power of the wind. The wind has had an important part in their final form, since it has gathered up the dry sand left above the ordinary action of the wave and piled it, as at Midway, in the center of a secure enclosure, formed by an encircling coral reef, or as at Laysan, to form a sand rim about an elevated coral lagoon.

Lying between the group of low islands and forming a connecting link with the high or inhabited group, are five islands, the lowest of the high islands. They form a transition group between the coral and the volcanic islands and a second division of the leeward chain, and are made up of Gardner Island, 170 feet high; French Frigates Shoal, 120 feet high; Necker Island, 300 feet high; Frost Shoal, and Nihoa or Bird Island, 903 feet high.

Together with the low islands, they form the leeward chain of thirteen islets, reefs and shoals that have a combined area of something over six square miles, or about four thousand acres. With the exception of Midway, which is the relay station for the Commercial Pacific Cable Company's wire across the Pacific, they are uninhabited at the present time. The entire chain, with the exception of Midway, has been set aside by the federal government to form the Hawaiian Islands Bird Reservation, which, taken collectively, forms the largest and most populous bird colony in the world.

To many these remote, shimmering, uninhabited islands are devoid of interest; to the naturalist, however, every square foot of the surface, and all the life that inhabits them, has an interesting story to tell. The geologist finds in them subjects of the greatest interest and importance. The thrilling story of their up-building through centuries by the tireless activity of the tiny animal, the coral polyp, that by nature is endowed with the mysterious power of extracting certain elements in solution from the sea water and little by little transforming them into a reef of solid lime-stone masonry, which, in time, becomes the foundation of inhabited land, is indeed most wonderful.

As the formation and growth of coral islands and reefs has been a subject profound enough to engage the attention of such thinkers as Darwin, Agassiz, Dana, Wallace, and a score of others, it is small wonder that these coral islands, which gem the surface of our summer seas, are invested with vital interest for those who feel a scientific concern in them and who are permitted to study them.

Ocean Island.

The leeward chain furnishes interesting examples of the various types of coral islands. Ocean Island, the extreme western end of the Hawaiian chain, lies in 178° 29′ 45″ west longitude, and 28° 25′ 45″ north latitude, and is almost at the antipodes from Greenwich, and, as it lies in the northern limit of the coral belt, it furnishes an excellent example of a circular barrier atoll in mid-ocean. The coral rim surrounds and forms a barrier about four small sand islets and is approximately sixteen miles in circumference. The rim is broken for a mile or more on the western side, but the lagoon enclosed is too shallow to admit the entrance of sea-going ships. Over this low coral rim the curving line of white breakers beat, forming a snowy girdle about the low islets that lie protected within.

Midway Island.

Midway Island is fifty-six miles to the east of Ocean Island, and, like it, is made up of a low circular coral rim or atoll, six miles in diameter, averaging five feet in height by twenty feet in width, which is open to the west. Like Ocean, it has one fair-sized sand islet and one that is covered with shrubbery. These islets lie in the southern part of the circle, about a mile apart, and are utilized as stations by the cable company. The coral rim encloses an area of about forty square miles of quiet water which attains a depth of eight fathoms. The island was discovered in 1859 by Captain Brooks, who took possession of it for the United States. Attempts to utilize it as a coaling station were abandoned after a single trial; but in 1902 it was successfully occupied by the cable company, and has since been regularly visited by vessels carrying provisions and supplies.

Just prior to my visit in 1902, which preceded the arrival of the cable by a few months, the island had been visited and devastated by a party of poachers engaged in securing birds' feathers for millinery purposes. The dead bodies of thousands of birds, ruthlessly slaughtered by them for their wings and tails, were thickly strewn over both islets. The reports made at the time, by the writer, to the State Department and various officials in Washington, was the first step in the long campaign that finally resulted in the establishment of the Hawaiian Islands Bird Reservation.

Gambier Shoal.

Gambier Shoal is a circular atoll lying about half way between Midway and Pearl and Hermes Reef. The latter is an irregular oval atoll, about forty miles in circumference, which encloses a dozen small islets of shifting sand. It was

discovered in 1822 by two whaling vessels, both of which were wrecked on the reef the same night within ten miles of each other, thus giving the reef its double name, and establishing a record for the locality that has served as a danger warning to mariners even to the present day.

Lisiansky, discovered in 1805 by a Russian, for whom it is named, is a small oval island composed mostly of coral sand. It is about two miles by three miles in extent and is surrounded by shallow water, but is without a central lagoon. Like Midway and Laysan, it has been visited by bird poachers from time to time. In 1905 a party of Japanese were found on the island engaged in killing birds for the millinery trade. It was estimated by the officers of the U. S. Revenue Cutter Thetis, who arrested the offenders, that they had killed three hundred thousand birds during the season.

LAYSAN.

Laysan Island was an American discovery, made in 1828, and named by the captain for his vessel. It was taken possession of by the Hawaiian Kingdom and later proved to be a rich guano island. For years it was leased to a firm in Honolulu, which removed thousands of tons of valuable fertilizer from it. Laysan is about two miles long by a mile and a half in breadth. The writer has estimated that during the year 1902 it was inhabited by ten million sea birds that roam over the central north Pacific Ocean. This island differs from those previously considered in that it is unmistakably an elevated coral atoll, since it holds in its center a large briney lake, that has its surface slightly above the level of the sea that surrounds the island. The evidence seems to indicate that what was a low atoll at some remote period, possibly during the late Pliocene, was elevated and transformed, so that the atoll became a lake in mid-ocean surrounded by a ring of coral sand. The island is in turn practically surrounded by a coral reef with here and there an opening of sufficient size to admit a small row boat.

The harbor is on the southwest side and affords a safe anchorage in the lee of the island. The island has been more or less continuously inhabited for a number of years, and has been visited on several occasions by naturalists, so that its fauna and flora have been more fully studied and the island made more widely known than any of the other islands in the leeward chain. In another connection the remarkable bird population for which Laysan is justly famous has been referred to at some length.

The guano deposits have been very extensively worked and may now be regarded as practically exhausted. The beds were located on the inner slopes of the sand rim of the island at each end of the lake or lagoon. Originally they were from a few inches to two feet in thickness and varied greatly in the percentage of phosphate of lime—the valuable property for which they were worked. The bones and eggs of the birds whose excrement, in combination with the coral sand, formed the rich calcium phosphate or guano fertilizer, were

PLATE 21. REEFS AND ISLANDS IN THE LEEWARD CHAIN.

1. Bird Island [Nihoa] (volcanic) from the northwest. 2. Seal on beach at Pearl and Hermes Reef. 3. Necker Island, (low volcanic island) south side. 4. Skinning a seal on Pearl and Hermes Reef. 5. French Frigates Shoal (volcanic formation).

often found in these beds in a semi-fossilized state, pointing to the way in which similar fossils have been embedded elsewhere in much older deposits.

The rate of deposition of this valuable fertilizer is necessarily very slow and is in direct proportion to the bird population. While it continues to be deposited, the amount is small as the colony has been seriously interferred with owing to the slaughter of the greater number of the large albatross, which doubtless have always been the chief factors in guano production in these waters.

Maro Reef was also the discovery of an American whaling ship in 1820. It is a rough quadrangular wreath of white breakers, about thirty-five miles in circumference, with no land in sight.

Dowsett Reef is but thirteen miles south of Maro, and like it, is evidently a young reef as compared with Laysan, since only a few rocks are awash here and there above the breakers. It was named for Captain Dowsett of the whaling brig "Kamehameha," whose vessel struck on the reef in 1872.

Gardner and French Frigates Shoal.

Coming next to the second division of the leeward chain, we find, with the possible exception of Frost Shoal, which is thirteen miles southwest of Nihoa, that they are no longer wholly of coral formation. Gardner, the first of these islands, is a cone-shaped rock 170 feet high by 600 feet or more in diameter. There is a small island lying a short distance to the east of the main rock, but deep water comes up close to the main island on all sides, and vertical sea cliffs, sixty or seventy feet high, surround it on all sides. It was discovered by an American whaler in 1820, but has seldom been visited since. This is the first exposed evidence of volcanic rock to be met within the chain, and is of special interest, since it is more than 700 miles east and south of Ocean Island, and is at least 600 miles northwest of Honolulu. Such facts give the reader an idea of the magnificent distances one encounters in traveling through the length of the Hawaiian group. It also emphasizes the extent and magnitude of the chain of volcanic mountains submerged in the central north Pacific, of which, according to the legend of Pele's coming, previously related, and the opinion of learned geologists, only the tops of the tallest peaks are exposed.

The French Frigates Shoal [2] is about thirty square miles in extent and was discovered by the great navigator, La Perouse, in 1786, and by him named for the two French frigates under his command. A striking volcanic rock, 120 feet high, rises from the lagoon, which is filled with growing reefs and shifting sand-banks. The surrounding reefs form a barrier about the volcanic point within and is perhaps the best example of this form of reef in the group.

Necker Island.

Necker Island was discovered in 1786, during the same expedition that made the French Frigates Shoal first known to the world. It was named by the discoverer for the great French statesman and financier who convened the

[2] Not Frigate as usually written.

French States-General in 1789. The island, as shown by the steep sea cliffs, is the remains of a soil-capped volcanic crater, that is about 300 feet high, three-fourths of a mile in length, by 500 feet in width, at the widest part. It is surrounded by shallow water; there being an extensive shoal, principally on the south side.

This island and near-by Nihoa, or Bird Island, are of special interest as they were visited in ancient times by hunting and fishing parties from Kauai, who made the journey to it in their outrigger canoes. As Necker is 250 miles distant from the nearest inhabited island,[3] the journey thither would seem to be one not to be lightly undertaken. But as the island was one of the few sources of supply of the coveted frigate and tropic bird feathers much used in their feather work, the journey seems to have been made more or less regularly.

The level portion on top of the island of Necker is more or less covered with a number of curiously formed stone enclosures, which may have been temples,[4] in which have been found several remarkable stone images, fifteen inches or more in height. These, together with a number of curiously formed stone dishes with which they were associated, are now in the Bishop Museum. They are of such unusual design and workmanship as to make them appear relics of some race other than the Hawaiian. However, as the Hawaiian is the only race known to have visited these remote islands at so early a period, and as they were by nature a very religious people, there still remains the possibility that the relics, including the stone enclosures, if not of their making, were at least known to and probably made use of by them.

Nihoa.

Nihoa completes the list of the leeward uninhabited islands of the Hawaiian group. It is 150 miles east of Necker and 120 miles northwest from Niihau, the nearest inhabited island. It is the highest island in the leeward chain, its summit being a pinnacle at the northwest end which rises 900 feet above the sea. The island is about a mile in length by 2000 feet in breadth, which gives it an area of 250 acres. It is unmistakably the eroded remains of a very ancient and deeply submerged crater, the outer slopes of which have been worn away, leaving only a portion of the familiar, hollowed, volcanic bowl. The materials of which it is composed are similar to those of the high islands, and there is every evidence that it is even more ancient than Kauai.

Dr. Sereno Bishop, who visited it in 1885 as the geologist of a party, headed by the then Princess Liliuokalani, declared the island to be a pair of clinker pinnacles out of the inner cone of a once mighty volcanic dome, which has been eaten down by wind and rain for thousands of feet during unreckoned ages. From the large number of basaltic dikes which cut the island from end to end, he was led to infer that Nihoa is the result of an extremely protracted period of igneous activity. Perhaps this hoary remnant of the past may at one time

[3] Niihau. [4] Heiaus.

have been a stately island, like those of the inhabited group with which we are familiar, that through submergence and erosion, has been reduced almost to sea-level.

CHAPTER IX.

THE INHABITED ISLANDS: A DESCRIPTION OF KAUAI AND NIIHAU.

Hawaii-nei: Position of the Inhabited Islands.

The wonderful group of high, inhabited, volcanic islands over the formation, or at least the completion, of which the Hawaiians believed Pele presided, consists of the islands of Hawaii, Kahoolawe, Maui, Lanai, Molokai, Oahu, Kauai and Niihau, together with several smaller islands scattered about them. Taken collectively they form the Hawaiian group as it is generally understood, or as the natives expressed it, "Hawaii-nei," meaning all Hawaii. They are anchored far out in the middle of the north Pacific, under the Tropic of Cancer, and extend in a northwesterly direction from Hawaii, the southern most, to Niihau, a distance of about 400 miles. Honolulu, the capital and principal port of the Territory of Hawaii, is located on Oahu. The position of the Territorial observatory in the capitol grounds in Honolulu is in W. long. 157° 18′ 0″ and N. lat. 21° 18′ 02″, and is at a point about fifty miles north and west of the geographical center of the inhabited group.

Like most volcanic islands, the Hawaiian Islands lie in a more or less straight line; or to be more exact, in two nearly parallel lines, and are supposed by some to be superimposed over a great crack in the ocean's floor, and by others to rise from a submerged plateau.

Looking more broadly at the group in its relation to the rest of the world, we find the islands situated at the cross-roads of the Pacific Ocean, 2100 miles southwest from San Francisco and eleven days' journey by the fastest train and ship, from New York. They are planted far out in the deep blue waters of the Pacific and are the most isolated islands in the world. It is twelve to eighteen thousand feet down to the ocean's floor on all sides of the group, and, as has already been said, it is believed that all of the islands are the exposed summits of gigantic mountains that rise more or less abruptly from the very bed of the Pacific Ocean.

This chain of fantastically sculptured volcanic mountain peaks, is made up of fifteen great craters, of the first magnitude, all of which at one time or another have been active. All but three of them, however, have been dead and extinct for centuries, perhaps thousands of centuries. Fortunately all three of the active volcanoes are located on Hawaii, the southernmost, and undoubtedly the youngest island of the group.

Since Honolulu is ordinarily the point of arrival and departure for trans-Pacific steamers, as well as inter-island boats, it is well to make it the center

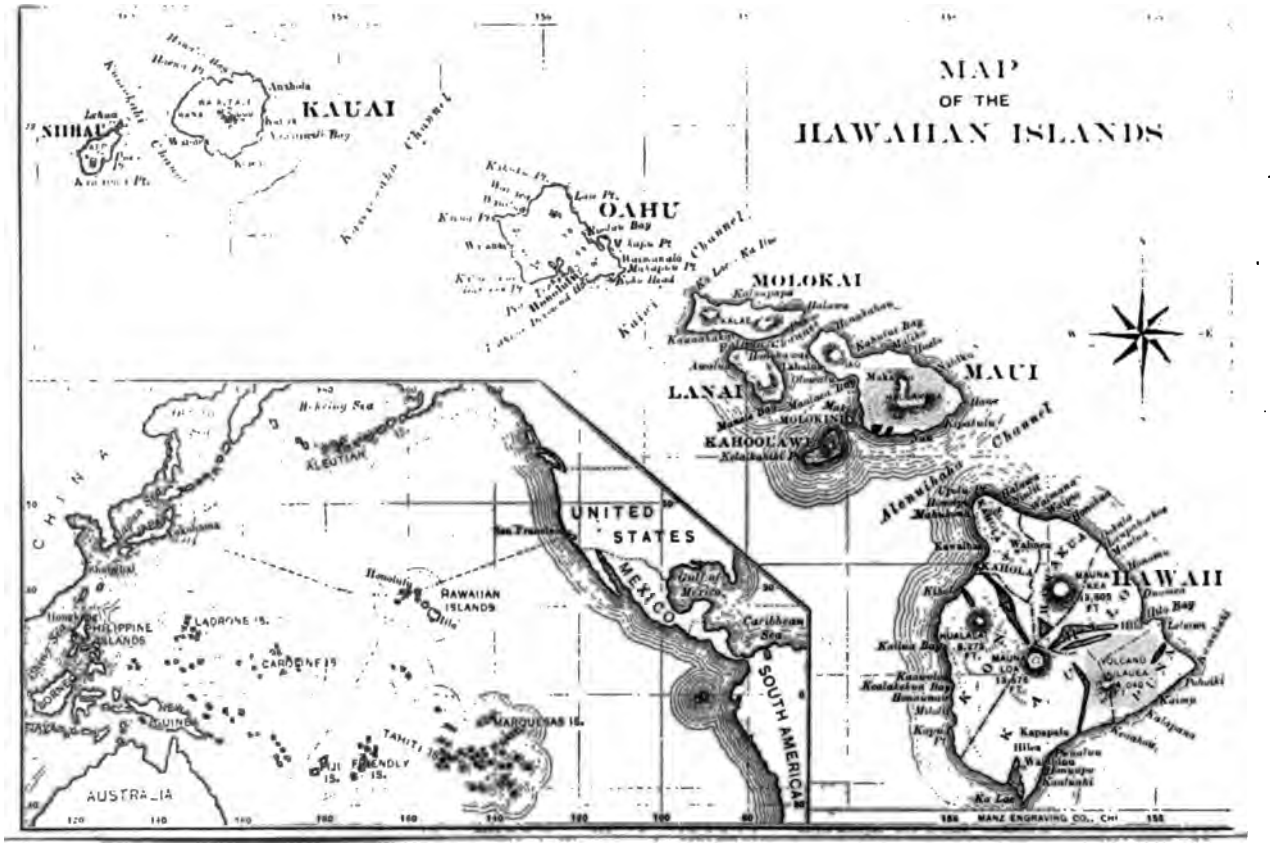

PLATE 22. MAP OF THE HIGH OR INHABITED ISLANDS OF THE HAWAIIAN GROUP.

from which to study, in some detail, the main geographic, topographic and geologic features of the group.

NIIHAU.

To the northwest of Honolulu lie the islands of Niihau and Kauai. The former, the farther removed of the two, is in a northwesterly direction from Honolulu and is in line with the islands mentioned in another chapter as forming the leeward chain. It is seventeen miles west of Kauai from which it is separated by a very deep ocean channel. It is about eighteen miles long by eight miles in width, at the widest part, and has an area of ninety-seven square miles. The highest portion attains an elevation of about 1300 feet above sea level.

The island consists of a high central section called Kaeo, surrounded by a plain on three sides. On the north and west sides it is the highest and it is here that steep cliffs occur where the high land joins the summit flat. The higher part is irregular and of a basaltic origin, but is without the sharp peaks that characterize some of the larger islands. A large, natural pond near the center of the island and several smaller ponds and artificial reservoirs are found in various sections.

While Niihau shows evidence of great erosion it is evident that its moderate height and small size has prevented it receiving the abundant rainfall which has been an important factor in aging its larger companions.

A large part of the island is low, apparently of coral or æolian origin, and is the inhabited section. The island is now utilized as a great sheep ranch, there being extensive areas of grass land, especially suited to grazing. Perhaps 150 natives, mostly comparatively new arrivals, now inhabit the island, and together with the old inhabitants, all told, are but a remnant of the thousand sturdy Hawaiians who made it their home less than seventy years ago. The island is noted in the group as the one on which is found the famous sedge from which the natives weave their serviceable soft grass mats, although the same plant occurs in suitable localities on all of the islands. The beaches are strewn with beautiful, though small, sea shells, known as Niihau shells,[1] which are strung into long necklaces called Niihau leis.

Near Niihau are two cinder cones, Kaula on the west and Lehua on the northeast, which form small detached islands. Prof. Hitchcock says, "The first is about the size and shape of Punchbowl, cut in two and the lower half destroyed by the waves. The concentric structure of the yellow cinders, much like the lower surface of Koko Head, is very obvious. Lehua appears to be a similar remnant, less eroded, as it has maintained about 200 degrees of its circumference instead of the 140 degrees of Kaula. Both these crater cones have the western or leeward side the highest, because the trade winds drive the falling rain of ashes and lapilli in the direction of the air movement, building up a compact laminated pile of material to leeward. The subsequent erosion

[1] *Columbella varians.*

PLATE 23. VIEWS ON KAUAI.

1. Wild mountain scenery along Olokele Cañon. 2. View from the mouth of Wailua stream. 3. The village of Hanamaulu. 4. Wailua falls. 5. View along the coast at Hanalei.

by the waves fashion a crescent-shaped island opening to the winds and surges upon the northeast side."

Kauai—The Garden Island.

Kauai, next to the smallest of the five large islands, seems to agree with Niihau in age of formation. In fact, it is suggested that some great force has torn the smaller island away from the larger one without disturbing the strata of either. It is nearly circular and at the same time roughly quadrangular in form. Excepting the Mana flats, which seem to be uplifted coral reefs, the island could all be included within a circle, with a radius of fifteen miles, using Waialeale, the highest point, as the pivot. It is a beautiful, rich, well-watered island clothed with varied and luxuriant verdure and as such is often spoken of as the "Garden Island" of the group. Disintegration of the lava has proceeded farther here than on the other islands, a fact, taken in connection with other data, as indicating that the volcanic fires died out first at this end of the chain.

The coast is singularly regular in outline, there being no extensive bays or pronounced points or headlands. Except along the northwest side of the island, at Napali, where there are fifteen miles or more of picturesque sea cliffs, the coast lands are comparatively low and flat. The shore-line is free from coral reefs, presumably owing to the depth of water near the shore. In general the main contour of the island slopes rather gradually from the summit of Waialeale, at an elevation of 5250 feet, down to the sea, though ridges and corresponding valleys radiate spoke-like in all directions.

The eastern and northern side of the island, as is the case with all the islands, has been drenched by tropical rains for countless centuries with the result that erosion by wind and rain is most marked on that side of the island. The original slopes on the windward side of Kauai have been almost entirely eroded, leaving only a few short spur-like ridges. On the opposite or leeward side; however, the erosion is not so marked nor so far advanced, as the deep gorges with wide level spaces between them indicate. These gorges are deep and cañon-like, inland, but, as they near the sea-coast, their sides become less precipitous and finally loose their character as the valley reaches the coastal plain.

Waialeale Mountain.

Geologists agree that the central dome of Waialeale must have been much higher than now, and that the disintegrated lava has been washed from its summit to form the rich soil that makes up the coastal plain. The effects of erosion have been considered as perhaps the best evidence of the age of the Hawaiian mountains, and this great mountain worn to the core with its one-time lofty central crater eaten down to form a slimy bog on its summit, points to the great antiquity of the island under consideration. The gnawing action of wind and rain leaves only the more resistant ridges, as the old mountain is thus slowly

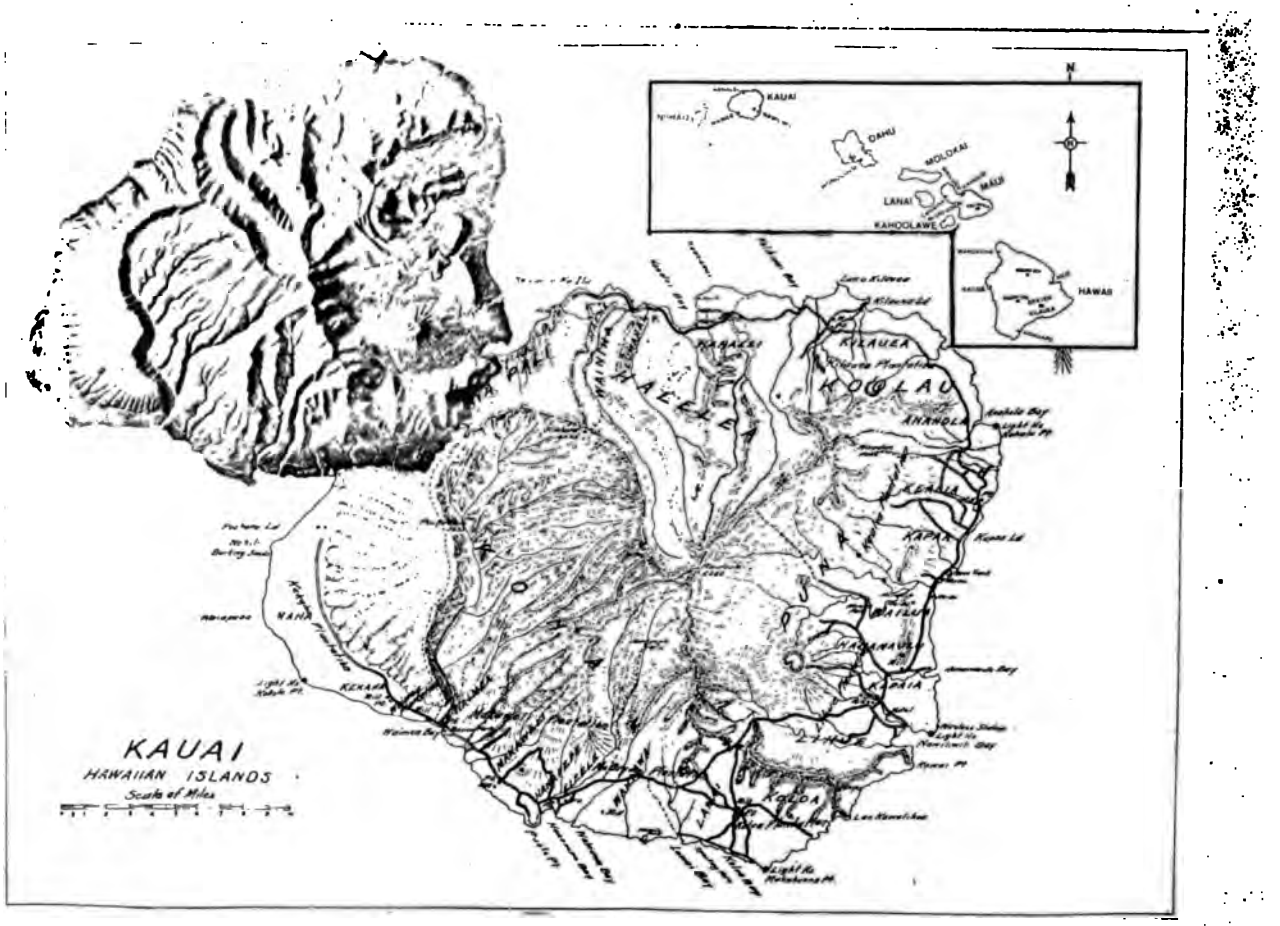

PLATE 24. MAP OF THE ISLAND OF KAUAI.

eaten away. This has progressed on Kauai until only the skilled geologists can, in fancy, reconstruct its original dome-like outlines.

Everywhere in the group, but especially on Kauai, is found excellent examples of one-time solid rocks which are passing into fertile soil through the ordinary agencies of disintegration. In its earlier stages the new-formed soil is open and porous like a gravel bed. In this condition it absorbs large quantities of moisture which rapidly seep away from the surface. The power of lava soils to retain moisture varies with the mechanical state of the soil and the amount of organic matter it contains. While the soil under cultivation on Kauai is very fine, and for that reason retains water reasonably well, it is, in most cases, very red in color, indicating that it has not been discolored by the impregnation of vegetable acids, which in the forests and beds of valleys is very liable to produce a characteristic black soil.

Lava Soil.

Generally speaking the soil on Kauai is everywhere good, but is light and open, and requires much irrigation to make it fertile. The constant cultivation of the land does much to improve the soil, and by the addition of carefully compounded fertilizer and an abundant supply of water, enormous yields of sugar-cane are secured. The growth of various crops affect the soil differently, as they remove from it varying amounts of nitrogen, phosphoric acid, potash and lime, which are the principal elements required by plants as food. Careful experiments have shown that the amount of these elements removed varies greatly even with the different varieties of cane that are grown in the islands. As a result, the care and proper fertilization of the soils of the group has been the subject of much scientific study.

While the main central dome on Kauai is the most conspicuous natural feature, there are other important elevations. The Hoary Head range, which extends down to the coast at Nawiliwili Bay, may be considered as part of the backbone of the main mountains. The highest point on this ridge, Haupu, is 2030 feet; but between this point and the central dome the ridge is much lower, forming a pass for the Government road from Lawai to Lihue.

Secondary Volcanic Cones.

A number of secondary volcanic cones on Kauai are important in the general topography of the island. The largest of these is Kilohana crater, which rises from the level Lihue plain to a height of 1100 feet. The ejecta from this cone has been thrown over the country-side roundabout within a radius of four or five miles. In the neighborhood of Koloa are several small secondary volcanic cones within the radius of a few miles. The lava emitted by them was black and of a peculiar ropey type. Along the sea-shore the sea water forces its way under the surface and is often expelled through holes and openings in the lava in this vicinty. At favorable seasons the water spouts high in the air, forming great fountains termed "spouting horns."

PLATE 25. CANONS AND VALLEYS ON KAUAI.

1. View in Olokele Cañon. 2. The Hanalei River. 3. View in Waimea Cañon.

A great central forested bog, or morass, extends for miles along the top of the precipice which bounds the Wainiha Valley on the northeast. It slopes gradually to the southwest, and provides the natural storage reservoir for the headwaters of the Waimea, Makaweli and Hanapepe rivers. This bog forms one of the least known, most dangerous and thoroughly inaccessible regions in the entire Hawaiian group. The writer, with an experienced native guide, spent three weeks in the region in the spring of 1900, and amid chilling rains and bewildering fogs made an expedition extending through four days over miles of quaking moss-grown bog to a point designated by the guide as the summit of Waialeale. We were never out of the dense fog during the expedition, and that we returned to our camp and to civilization at all has always seemed little short of the miraculous.

In many sections the thin turf, which covered the quagmire beneath, would tremble for yards in all directions at every step, and too often at a false step from the proper route, would give way, plunging us hip deep in the mire. Our chief concern was to locate reasonably solid ground, a necessary precaution that entailed many weary miles of wandering in the weird moss-grown wilderness, with attendant hardships and hazardous experiences that are still vivid in memory.

Cañons of Kauai.

The numerous valleys and cañons of Kauai, and their attendant streams have justly been celebrated for their beauty and grandeur. Waimea is one of the finest, since it has cut its way between perpendicular walls which are several thousand feet in height at the head of the stream. The scenery along the Makaweli and Olokele cañons, tributaries of the Waimea system, and the Wainiha gorge, is the equal of the most rugged and magnificent mountain scenery anywhere in the world, and well repays the traveler for the effort made to view it.

The great Hanalei Valley, on the northern side of the island, is noteworthy for its scenery, its waterfalls and its stream, which is the largest river in the group, being navigable by small boats for about three miles. Wailua and Hanapepe are beautiful valleys, made more beautiful by their splendid waterfalls. Several of these streams, notably Hanalei, and the Hanapepe stream opposite it, give evidence of being drowned valleys, as in each case a broad intervale extends for a considerable distance inland.

The Napali Cliffs.

The region of Napali, on the northwest side of the island, is difficult of access and, unfortunately, is seldom seen by the traveler. The section is given over by nature to a series of short, deep amphitheater-shaped gulches that show marks of profound erosion, leaving the region with some of the most awe-inspiring scenery on the islands. Returning from a cruise down the leeward chain, the writer had an opportunity to view the wonderful scenery of Napali at its best, from the vantage point of the deck of the vessel, at close range under

the most favorable conditions. The late afternoon sun was lighting the bold headlands and the fantastic fjord-like valleys—in a way to accentuate every detail of the singularly charming and beautiful panoramic view. The splendor of Kalalau valley, the largest and perhaps the most wonderful of them all,—a valley of grandeur, golden light, purple shadows, and sunset rainbows,—was a welcome change after the daily monotony of the open sea on a long, lonely, though happy voyage.

The Barking Sands.

Among the natural features of Kauai of considerable geologic interest should be mentioned the barking sands of Mana. They consist of a series of wind-blown sand hills, a half mile or more in length, along the shore at Nahili. The bank is nearly sixty feet high and through the action of the wind the mound is constantly advancing on the land. The front wall is quite steep. The white sand, which is composed of coral, shells and particles of lava, has the peculiar property, when very dry, of emitting a sound when two handfuls are clapped together, that, to the imaginative mind, seems to resemble the barking of a dog. When a horse is rushed down the steep incline of the mound a curious sound as of subterranean thunder is produced. The sound varies with the degree of heat, the dryness of the sand and the amount of friction employed; so that sounds varying from a faint rustle to a deep rumble may be produced. Attempts at explaining this rare natural phenomenon have left much of the mystery still unsolved. However, the dry sand doubtless has a resonant quality that is the basis of the peculiar manifestation, which disappears when the sand is wet. That the barking sands are found in only a couple of the driest localities in the group is also significant. Much of the shoreline of Kauai, for example, is lined with old coral reefs that have partly disintegrated into sand that forms the beaches. This sand, as æolian deposits, is often carried inland for considerable distances, and though composed of the same material, it has none of the peculiar qualities of the sand at Mana.

Spouting Horn—Caves.

The blow hole, or spouting horn, is a familiar natural curiosity fairly common in the islands. Famous ones at Koloa, mentioned above, have long been objects of interest to travelers. At half-tide, particularly during a heavy sea, the larger ones throw up fountains from openings five feet in diameter, that often rise as a column of water and spray fifty or sixty feet in height. The sound of the air as it rushes through the small crevices is most startling to the spectator, who feels the rocks beneath his feet tremble as shrill shrieks and various uncanny noises are produced by the wild rush of the water into the cave below him. These caves are usually bubbles in the lava stream, or sometimes they are formed by the washing away of the loose pieces of rock underlying the more solid outer crust of the old lava flow.

The caves in the cliffs of Haena are among Kauai's numerous places of

geologic interest. Two of these are at sea level and are filled with water. In one the water is fresh, in the other it is salt. In many places the roof of the caves are encrusted with mineral deposits, sometimes several inches in thickness. The lower caves can only be entered at certain tides and under favorable conditions. However, they are known to be old lava conduits and evidently extend back into the cliff for some distance.

In several places in the group, but notably in Hanapepe Valley, columnar basalt occurs. These curious prisms are from ten to eighteen inches in diameter with sides from five to seven feet in length. They are rude six-sided columns which appear to be due to the peculiar contraction of the lava, usually under pressure, as it cools.

CHAPTER X.

ISLAND OF OAHU.

For obvious reasons the formation of Oahu, the metropolis of the group, has received much attention from various observers, with the result that its topography and geology are better known than is the case with any of the other islands.

A Laboratory in Vulcanology.

Only a few of the more striking physiographic features of the island can be referred to here, but it is a fact that on Oahu the student of natural phenomena has a veritable open-air laboratory in vulcanology, stored with splendid specimens, showing practically every phase that results from volcanic activity and erosion.

Oahu is about fifty-four miles long by twenty-three broad in its greatest right angle dimensions. It has an area of 5,985 square miles, with a coast line of 177 miles, and has its highest mountain peak 4,030 feet above the sea. In outline it forms a four-sided kite-shape figure in which the four points might be said to correspond, in relative position, to the stars in the Southern Cross. Kaena, the northwest point of the island, is at the top of the cross; Makapuu, the southeast point, is at the bottom. Kahuku Point, at the northeast, and Barber's Point, at the southwest, correspond with the right and left hand stars in the astral figure. The shore-line of the island which connects these four main points is more irregular in outline than that of any other island in the group, a fact which has given to Oahu its valuable harbor facilities.

Honolulu Harbor—Pearl Harbor.

Beginning with Honolulu Harbor, situated at the mouth of the Nuuanu stream, and about midway along the southern side of the island between Makapuu and Barber's Point, we find the most important harbor in the group. It is formed by a sight indentation of the coast-line and is protected by a coral reef

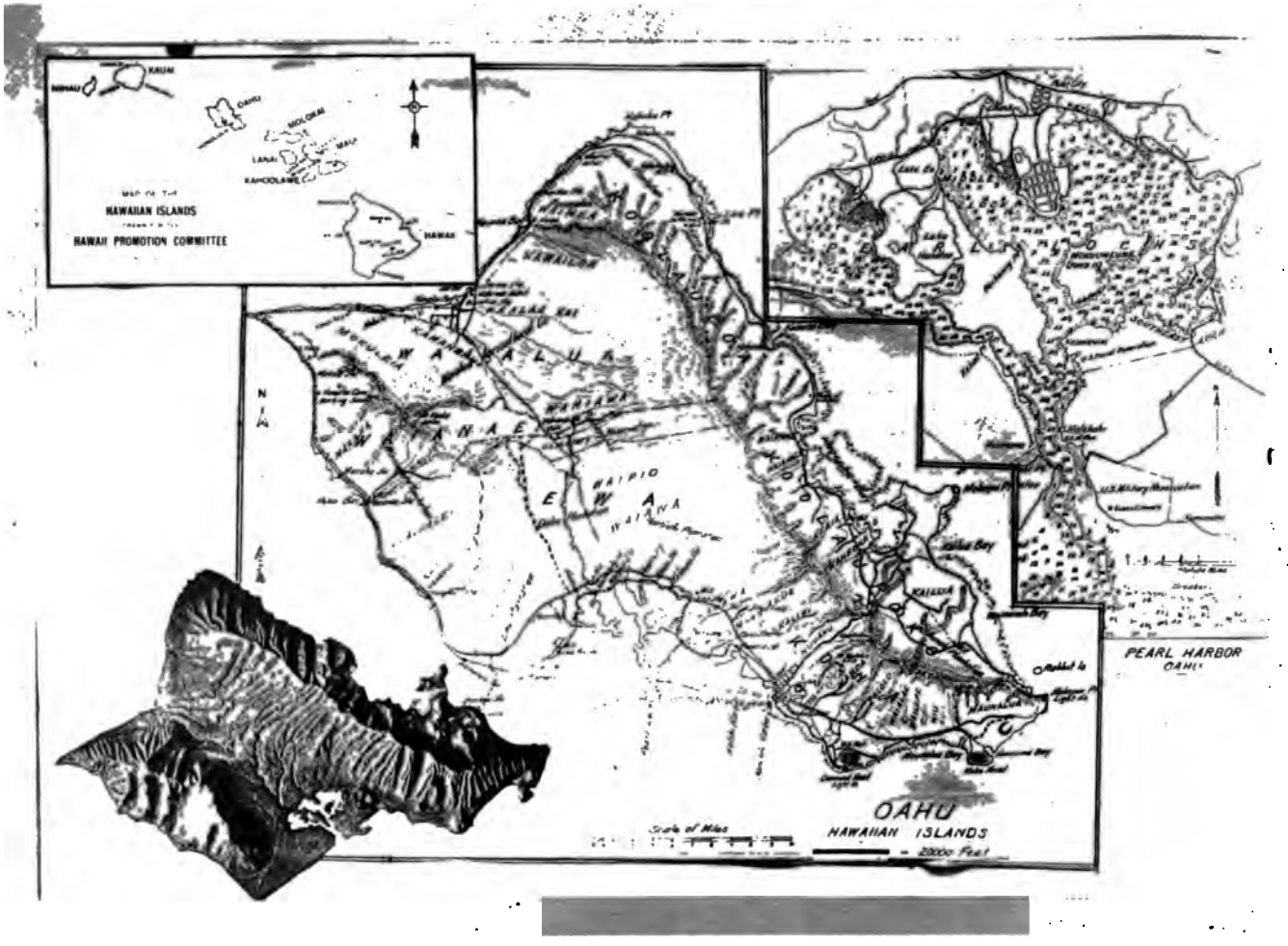

PLATE 26. MAP OF THE ISLAND OF OAHU.

that extends across the exposed sea-side. Through the reef an entrance has been kept open by the waters from Nuuanu and the adjoining stream, which, being fresh, prevents the growth of the coral. This natural entrance to the harbor, which has since been deepened and strengthened, was taken advantage of by the natives and by foreign vessels that visited the islands until, in time, the village on the shore grew into a prosperous city. The harbor derived its name not from the harbor itself, but from a small district along the Nuuanu stream a mile from the mouth,—"a district of abundant calm," or "a pleasant slope of restful land," that received its name in turn from a chief called Honolulu, whose name was formed by a union of two words, 'hono,' abundance, and 'lulu,' peace or calm; hence to speak of Honolulu as a haven of abundant peace and calm is but to transfer to the harbor a poetic descriptive name derived from the adjacent land.

Along the coast a few miles to the west is the entrance to Pearl Harbor, which is an enclosed body of water made up of two main divisions, known respectively as East and West Lochs, the latter being much the larger of the two. They combine to form a channel which also carries fresh water sufficient to keep open a passage, through the protecting coral reef, to the sea. This great land-locked harbor is now being developed by the Federal government, by dredging and fortifying its channel, with a view to making of it a great naval base for the United States, as well as the finest and safest harbor in the Pacific. On the opposite or windward side of the island are located Kaneohe Bay and Kahana Bay, both with extensive coral reefs across their mouths. The former, a large, beautiful sheet of water, is partially enclosed on one side by Mokapu Point, and on the other by Kualoa headland, but unfortunately it is filled with submerged coral islands, rendering it inaccessible except to small vessels. Waialua Bay, on the northwest shore, while formed by a pronounced curve of the coast-line, is in reality little more than an open roadstead where small coasting vessels can anchor and find shelter from the northeast trades that have full sweep down that coast. Other beautiful bays of much geologic interest and significance occur at various points. Among them should be mentioned Waimea, a few miles beyond Waialua, Laie and Kailua bays on the windward coast, and Hanauma and Waialae bays between Honolulu and Makapuu Point on the south coast.

The Koolau and Waianae Mountains.

Turning to the land itself we find the island formed by the union of two nearly parallel mountain chains. The Koolau Range stretches for thirty-seven miles along the northeast or windward side of the island and, extending from Kahuku to Makapuu points, forms the longest range of mountains in the Hawaiian group. Along the southwest side extends the Waianae Range, which is about one-half the length of the range along the opposite side of the island.

Without doubt, the Waianae Range is the older of the two, and with Kaala, the highest point on the island, as its central figure, the range furnishes topographic features of prime importance. Geologists believe this group of moun-

PLATE 27. VIEW IN NUUANU VALLEY NEAR THE PALI SHOWING THE PEAK OF LANIHULI.

tains to correspond in age with the central dome of Kauai and that an enormous amount of erosion has left but the skeleton of a vast dome that was much higher and more symmetrical than its time-scarred outline would now suggest.

It is thought that it was long after the Waianae Range[1] was formed as a separate island, before the Koolau Range,[2] began to build itself up above the sea to form an annex, as it were, to the original island which had Kaala as its center. Thus, according to Dana and other geologists, Oahu was formed as a volcanic doublet—the work of two volcanoes whose adjacent sides, by lava flows and by erosion, have been united in the plains of Wahiawa, but whose forms have been so eroded that the exact position and extent of their craters has not been indicated with certainty.

The Pali.

The magnitude of the second crater is perhaps best appreciated from the historic landmark and pass through the Koolau Range known as the Pali, a word signifying in Hawaiian, a steep precipice. The Pali is approached from Honolulu by a road five or six miles in length that winds up the floor of Nuuanu Valley until at an elevation of 1,207 feet, with the peak of Lanihuli,[3] on the left, and Konahuanui,[4] the highest peak in the Koolau Range, on the right, it suddenly ends in a vertical drop of 700 feet. Several miles of almost vertical basaltic cliffs,—the eroded walls of this vast crater—stretch away on either hand. The Pali is truly Oahu's scenic lion. It is a natural wonder, that as a genuine surprise has nothing to equal it in all the world. From its sheer edge, the splendid panoramic view of the windward side of the island is spread out at the observer's feet—a view of rugged mountains, of cliffs, of country side, of quiet bays, of coral strands, and of the open sea that has beggared the descriptive powers of the most gifted.

Here the observer comes to appreciate not only the stupendous constructive power of nature that has called the island into being, but also those destructive agencies which, through countless centuries have been tearing down the solid rock, disintegrating, transporting and distributing it according to well-established natural laws.

With its long, vertical crater wall standing abreast of the northeast trade winds, and with the elevation and other conditions favorable to bring about an abundant rainfall, the Koolau range, on the leeward side, especially, has been furrowed from end to end into a series of deep lateral valleys, separated from each other by nearly parallel ridges that are conspicuous and significant features of the general topography of the island. The larger and more important of these valleys and ridges have a general southwesterly trend. The streams which rise in the section between the Koolau and the Waianae chain, however, are deflected by reason of the high plateau at Wahiawa so that part of them enter the sea at Waialua, while others join in the Ewa district of the island

[1] Formed by an elliptic crater. [2] The remains of an elongated crater. [3] 2275 feet. [4] 3105 feet.

and find their outlet to the ocean through the great Pearl Lochs already mentioned.

The windward side shows plainly the full force of drenching rains[5] and the cutting winds, for the seaward surfaces are everywhere deeply eroded and the disintegrated lava removed, leaving a series of amphitheaters, narrow promontory-like outlying ridges and cliffs that mark the more resistant cores of the solid rock.

The erosion of the Kaala dome is not so easily understood since the greater excavations are on the west side, while the slopes which are to windward, that is towards the Koolau range, are more gradual. But as the Waianae Mountains are conceded to be much older than the opposite range it is presumed that the conditions which exist now are much modified from those that were in effect when the Waianae Range was first eaten down.

Smaller Basaltic Craters and Tuff-Cones.

While the main ranges already discussed are of first importance in the topography of the island, the later volcanic manifestations, especially of the series of basaltic craters and tuff-cones that mark the close of volcanic activity on Oahu, form striking objects in the general contour of the island.

The tuff-cones are the most numerous and conspicuous, several being in view from Honolulu. Of these Diamond Head, or Leahi, the famous landmark often spoken of as the sphynx of the Pacific, is the most noticeable. As the traveler approaches the island for the first time Diamond Head with its imposing, rugged outline is sure to attract attention; often, too, it is the last parting glimpse of Diamond Head from the distance, as the voyager leaves the island behind, that brings the full realization to mind of all that it typifies of the life in a tropic land that has so fascinated him that, wander where he will, Oahu's shores seem always to call him back again.

Diamond Head.

Diamond Head rises in bold relief from the shore-line beyond Waikiki, to the height of 761 feet. While its sharp outline may seem to suggest to some the appropriate and accepted popular name by which the point is known far and wide, the name was, in fact, derived from the excitement created through the discovery by sailors at an early day of small calcite crystals[6] that they thought to be diamonds.

This crater mountain looks from the outside to be solid rock, but in reality it is a great hollow oval tuff-cone, 4,000 by 3,300 feet in its diameters, with its elongation in the direction of the trade winds. Owing to the ejecta being carried by the prevailing winds when the crater was in eruption the southwest side of this and of similar cones on the island is considerably higher than is the opposite side. Inside the crater the walls slope gently to the center, where, near the eastern wall, during the wet season, there is, or at least there

[5] The annual rainfall at the Pali usually exceeds 150 inches. [6] Still to be had for the gathering.

was, a small fresh water lake, 200 feet above the sea, that was frequented by wild fowl at the proper season.

Dr. Sereno E. Bishop made Diamond Head the basis of a study calculated to show the brief time required for the completion of tuff-cones of similar form. He concluded that such a cone "could have been created only by an extremely rapid projection aloft of its material, completed in a few hours at the most, and ceasing suddenly and finally." Taking into account the extreme regularity of its rim and the uniform dip and character of its crater he proceeded, with a mathematical calculation, to estimate that the 13,000,000,000 cubic feet of material that forms its mass could have been raised to approximately 12,000 feet, and dropped into its present position in two hours' time, and he was inclined to increase the velocity of the ejecta and reduce the time to perhaps one hour Other geologists, however, are very likely to question the soundness of the conclusions drawn by Dr. Bishop since there is unmistakable evidence that it was in eruption a number of times with intervening periods of repose.

Punchbowl Hill.

Punchbowl Hill, with a form which suggests its name—lies just back of the city and is 498 feet high. It is similar to Diamond Head in form and structure and has in its outer wall on the town side, numerous seams filled with calcite. Much can be learned of the geology of the vicinity by the study of the cone itself and from the phenomena about it. Other tuff-cones are Tantalus, Salt Lake, and Koko Head; there are still others on the opposite side of the island at Kaneohe, as well as at the south end of the Waianae Mountains at Laeloa. Some of the cones in the latter region, however, are small basaltic craters, as are also the one on Rocky Hill in Manoa Valley, and the two small craters, Muumai and Kaimuki, on the ridge back of Diamond Head, to the east of Honolulu.

Elevated Coral Reefs.

Almost the entire shore-line of Oahu shows more or less evidence of elevated coral reefs. In the vicinity of Honolulu these reefs form the foundation on which much of the city it built. The elevated reefs are most extensive, however, in the vicinity of Pearl Lochs, where they are intimately associated with the sedimentary deposits, volcanic flows, decaying rock and volcanic ash. It is thought by Professor Hitchcock and others that this series of deposits began in the Pliocene period and that it and the older layers beneath may be a base on which the ejections that formed the volcanic island began to accumulate as indicated on Plate 75. The region about Pearl Harbor is one of much geologic interest, but is far too complicated in character to be readily interpreted by the casual visitor. Features of general interest, however, are that in many places as many as nine or ten stratified deposits may be seen in a vertical cut of forty or fifty feet, and that in the region, beds from one to three or four feet thick, of large oyster shells *(Ostrea retusa)* are exposed, far inland. According to the investigations of Professor Hitchcock, "the Pliocene area of Oahu coincides very

PLATE 28. WAIKIKI BEACH AND DIAMOND HEAD.

Waikiki beach is one of the finest bathing resorts in the world. Besides being of interest to geologists, the reef which stretches from the mouth of Honolulu Harbor to the point of Diamond Head is a splendid collecting ground for the marine zoölogist. It is from this locality that many amateurs gather their first specimens. Examples of almost all of the great orders of marine animals as sponges (*Porifera*); jellyfish, sea-anemonies, stony corals (*Coelenterata*); flat worms (*Platyhelminthes*); round worms or thread worms (*Nemathelminthes*); nemertians (*Nemertinea*); rotifers (*Rotifera*); moss animals (*Bryozoa*); gephyreans (*Gephyrea*); starfish, brittle-stars, sea-urchins, sea-cucumbers (*Echinodermata*); segmented worms (*Annelida*); chitons, snails, slugs, whelks, clams, mussels, oysters, scallops, cephalopods (*Mollusca*); the principal classes and families of the Crustacea including the crabs, spider crabs, hermit crabs, prawns, shrimps, mantis shrimps, sand hoppers and other curious forms; sea-squirts (*Tunicata*); sharks and typical fishes (*Pisces*) of almost every family, and sea turtles (*Reptilia*) occur at Waikiki. These may be seen alive, and in most cases be taken from the shallow waters on the reef or from the sand beach. The locality is also a famous collecting ground for the marine botanist, as it abounds in various forms of aquatic plant life, being especially rich in representatives of all the more important forms of seaweeds (*Algæ*).

nearly with the low land tract utilized for cane and sisal from Barber's Point to Koko Head; perhaps to the altitude of 300 feet entirely around the island." Small patches of the rock appear at Waianae, Waialua, Kahuku Plantation, Laie and other places on the northeast coast, the highest reef being on the southwest end of Mailiilii at 120 feet above the sea. The rock is also extensively distributed beneath the surface, as is developed in boring artesian wells.

Age of Oahu.

Dr. W. H. Dall, who also studied the deposits in the vicinity of Pearl Harbor and Diamond Head, found species of sea shells[7] seemingly extinct, which are referable to the Pliocene. In conclusion he says, "that the reef rock of Pearl Harbor and Diamond Head limestones, are of the late Tertiary age which may accord with the Pliocene of West American shores or even be somewhat earlier, and in the region studied there was no evidence of any Pleistocene[8] elevated reefs whatsoever. It is probable that Oahu was land inhabited by animals as early as the Eocene," which period preceded the Miocene, and marked the opening period of the Cenozoic era, or the era of modern life.

Black Volcanic Sand.

Over much of the region about Honolulu, but especially on the slopes of the Punchbowl and Tantalus group of cones, are to be found extensive deposits of black ash, a volcanic product usually formed from basalt when erupted in association with much steam. The maximum thickness of the deposits is exposed at the base of the Tantalus cone, in Makiki Valley, where a bed twenty-five feet thick occurs. This coarse-grained sand has found many uses in the city; such as in making sidewalks and grading roads, and to some extent as sewers in the early days, while recently it has been found to be of some value as a fertilizer owing to the presence of potassium. The sources of the deposits referred to seems to have been Tantalus and Punchbowl; but practically all of the smaller cones have given more or less volcanic ash, which varies in fineness and color, as well as in amount, in each eruption and at different times during the same eruption. On Punchbowl especially this ash overlays the tuff, and, owing to the pronounced weathering of the latter, it seems to indicate two quite distinct periods of activity from the same source, with a long period of time between them. In the first eruption the material came up through the sea as the character of the tuff deposits indicate, while the later eruption or eruptions, including the ash, the basalt-like dikes which radiate from the rim, as well as the cinder-like beds on the upper part of the rim, found its way up a pipe within the cone from a deeper source of basalt, apparently without coming in contact with the water of the sea or its limestone deposits.

Limestone is also abundant about the crater at Diamond Head, at Koko Head, and at the Salt Lake crater, where portions of the old reef are said to be present on the inside of the crater.

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[7] *Conus, Purpura, Chama and Ostrea* [8] The more recent glacier period.

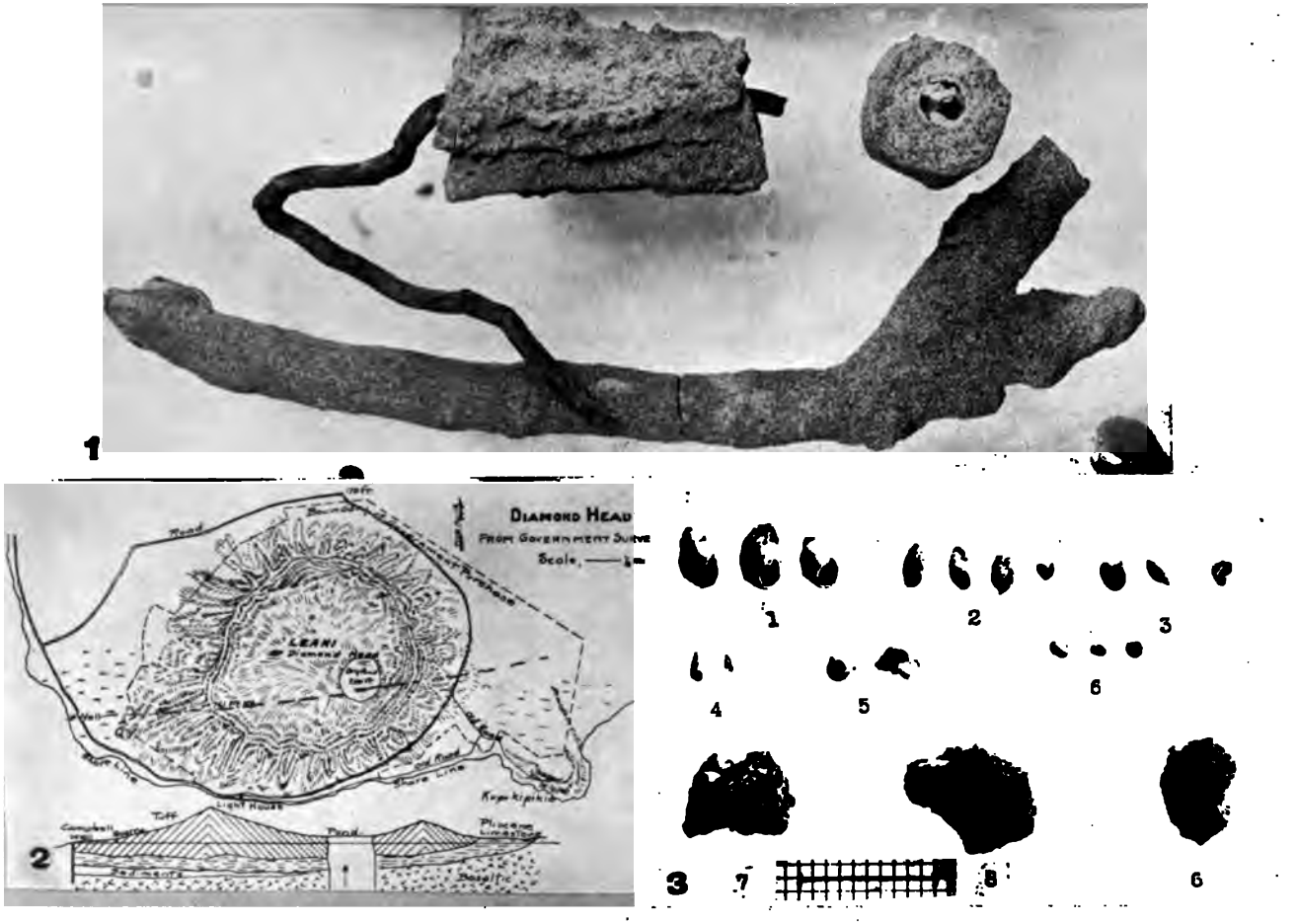

PLATE 29. SPECIMENS FROM DIAMOND HEAD.

1. Roots encrusted with sand forming root casts. 2. Vertical section and plan map of Diamond Head. 3. Fossil shells from the sea slopes of Diamond Head crater.

A matter of considerable interest has been brought to light through the excavations and road-cuttings about the base of Diamond Head, and especially at the quarries and sand pits opened there. The material of the lower slope is a talus made up of angular fragments from the slopes above, which is cemented into a brecciated mass, showing clearly that none of the angular particles have been rounded against each other, or by the action of water. In this mass have been discovered the remains of land shells of several probably extinct species belonging to well-known genera. Dr. Hitchcock concludes that the talus breccia at Diamond Head must be much newer than the date of the eruption of the tuff, since it is composed of fragments of that material from the older eruptions that are cemented together in the more recent talus. Considerable time must have elapsed between the ejection of the older material and the presence of the shell-bearing animals because the rocks must have been decomposed sufficiently to admit the growth of some vegetation on which the mollusks could live. From observations made in the same vicinity, and data gathered elsewhere about the island, but principally from the remains of the marine shells distributed inland over its surface, the same authority concludes that the whole of the island of Oahu must have been subsequently submerged for a brief period to a depth of two to three hundred feet, presumably during the Pliocene period. If so, it is concluded that the time of deposition of the land shells, found at the foot of Diamond Head, will be fixed at a period sufficiently remote to admit enough time to have elapsed since then to account for the development elsewhere on the island of the related and varied forms of land and tree shells[9] which, as we shall find in another chapter, have been much studied by many zoölogists, but especially by the world-renowned evolutionist, Dr. John T. Gulick, whose pioneer work in that important field of science has added so much that is fundamental to our understanding of the great laws of organic evolution.

Geologic History of Oahu.

In the preceding pages only a meager outline of the written evidence touching on the more salient points in the geologic history of Oahu has been attempted. Enough of the wonderful story has been given, however, to make it appear that the island was not in existence in its present form at the beginning, nor was it thrown up in its present form in a single mighty titanic convulsion of nature.

Let us review in their apparent natural order, some of the important chapters in nature's history of Oahu, for the facts which tell of the hoary events resulting in the formation of this wonderful island, with its charming scenery, are all written in stone, as it were, and may be read by those with skill and patience to decipher.

In the beginning the long Pacific Ocean swells doubtless rolled without interruption over the place where the island now stands. Just how long this condition lasted we can never know, but the evidence seems sufficient to Professor

[9] *Achatinellidæ.*

Hitchcock and others to warrant the conclusion that deposits of the Tertiary, perhaps the Eocene period, form the foundation on which the volcanic mass of the original island of Kaala was formed. These eruptive deposits began to be laid down under water, but in time the cone of Kaala built itself above the ocean perhaps three thousand feet higher than the tallest peak of the Waianae Range as we know it today. In reality the range is but the remains of a great dome, more or less symmetrical, that at first arose above the waters. By the erosive action of copious rains brought then as now from over the sea, it was deeply eaten away on all sides until its ancient form was very nearly effaced. During this period it slowly accumulated a stock of plants and animals from other regions, partly from other islands near and far and partly from the distant continents about the ocean.

Subsequently the island which may be called Koolau, only twenty miles to the north, was developed by a succession of eruptions, much as Kaala had developed before it, until its lavas and the soil eroded from them banked up several hundred feet about the foot of the older adjacent island-mountain, uniting the two islands into one and forming the plain of Wahiawa. It is asserted that Koolau extended farther northeast than at present and that the active center of the crater must have been beyond the foot of the Pali.

As soon as conditions became favorable, limestone began to form as coral reefs, probably first about the older island and later about them both. It has continued to be formed to the present day through the various chemical, physical and biologic agencies. Artesian well borings[10] and other sources of information have revealed data to prove that during this immensely long period the surface of the island stood much higher than at present.

The Pali crater and a doubtful crater near the head of Nuuanu Valley give evidence of periodic activity during this time, such as the eruption of the cellular or viscular lava, the formation of olivine laccoliths, and the intrusion of dikes of solid basalt that filled in fissures in the older mass. The last evidence of activity at the Pali appears in the form of an eruption of ash, clinkers and lava.

About this time Kapuai and Makakilo craters in the Laeloa region at the east end of the Waianae Range, and perhaps one or more of the Tantalus craters, were formed. Then came the ejection of some of the lavas met with in the sinking of artesian wells and the formation of certain of the Laeloa craters, also those at Kaimuki, Mauumai, and perhaps Rocky Hill, though Dr. Bishop places the eruption of the solid basalt which completely blocked the mouth of Manoa Valley at a much earlier period; but as its lower end extends a

[10] For example the famous geologic land mark, the Campbell well, at the west base of Diamond Head, after penetrating the surface gravel and beach sand for fifty feet and tufa, like Diamond Head, for 270 feet, entered a strata of "hard coral rock like marble" 505 feet thick. Stratas of dark brown clay, washed gravel, and deep red clay were below and overlaid soft white coral twenty-eight feet thick; beginning at 1048 feet below the surface, stratas of stone-like rock, brown clay, and broken coral were next penetrated, when the drill entered the first hard blue lava at a depth of 1223 feet. A thin strata of black and red clay was passed through, and the boring stopped at 1500 feet, after entering 249 feet into brown lava. Numerous other wells in different parts of the island show similar, though varying, evidence of deeply submerged coral beds which, as they form only at or near the surface, bear mute testimony of the periodic subsidence of the island.

short distance over the elevated reef at Moiliili, Rocky Hill must have been in eruption after the reef was formed.

Next came the period of the eruption of the tuff craters: the Salt Lake group, Punchbowl, Diamond Head, Koko Head, the Kaneohe group and other smaller craters of similar character. During this period the tuff came up through coral reefs, the land as we know it being submerged in the region of eruption. Then followed a long period of decay and the disintegration of the older eruptions and the newer tuff-cones of sufficient duration to produce soils from them. This period culminated in the discharge of ashes from Tantalus, Punchbowl, Diamond Head, Koko Head and other members of this group of craters, which terminated usually in a more or less extensive shower of volcanic stones. Dikes were then intruded into crevices, cutting Punchbowl, Diamond Head, and the coral reefs at various points, notably at Kaena Point, Kupikipikio and Koko Head.

Time then elapsed for the accumulation of calcarious talus breccia with soil and vegetation on the lower slope of Diamond Head sufficient to support several species of land shells. Then apparently came the depression of the whole island during which time the ocean encroached on the land above its present level, submerging the low lands about the island. This comparatively brief period left ocean deposits and slight wave markings about the new shore line, which, when the island was again elevated to its present level, was marked by ocean-flooded sand dunes—over which more recent dunes have been piled by the action of the wind. Lastly comes the long periods of disintegration, the formation of surface soil and finally human culture. While geologists may disagree, and there is much ground for disagreement, in the interpretation of the records in minor matters, all are agreed in the main points, and freely state that almost inconceivable time has elapsed since the oldest part of Oahu first emerged as a volcanic island.

Theory of the Formation of the Group.

Among the various theories that have been advanced in attempts to reconstruct the past history of the group, one of great interest and significance has recently been brought forward, in a very concrete form, by Dr. Henry A. Pilsbry, that has as its basis an exhaustive study of the Hawaiian land shells.[11]

He finds this interesting portion of the fauna belonging chiefly to a branch of a very ancient group[12] of land mollusks that are distributed on various islands of the Pacific. As there is a marked absence of modern types of land mollusks—save those that have been introduced through commerce—he feels that the peculiar fauna cannot be considered as springing from accidental introduction in the group from time to time in the remote past. By analogy the conclusion is arrived at that "the *Achatinellidæ* had already differentiated as a family before the beginning of the Tertiary." But the close relationship of the

[11] *Achatinellidæ.* [12] *Orthurethra.*

PLATE 30. SCENERY ON OAHU.

1. The Natural bridge at Makaha. 2. Waianae mountains from the railway. 3. The barking sands near Makua Station. 4. Surf along the coast near Kaena Point.

genera of the sub-family *Amastrinæ* and the even closer relationship of the genera of the related sub-family *Achatinellinæ* "indicate a sudden rejuvenescence of the old stock in comparatively modern[13] time." A study of the species, varieties and forms extant show that everywhere intense local differentiation is still in progress.

Dr. Pilsbry concludes that "the logical geographic boundaries of most of the species of *Achatinellidæ* give excellent ground for the belief that the present distribution of all the larger species has been attained by their own means of locomotion and that unusual or so-called accidental carriage, as by birds, drifting trees, etc., has been so rare as to be negligible. No evidence whatever of such carriage is known to me."

After exhausting the possibilities of accidental introduction of species from island to island, the conclusion follows that all of the important islands must have been, at one time, connected by land, and that distribution of the ancestral forms of land shells from Kauai to Hawaii was effected at that time.

As the Hawaiian chain, from Ocean and Midway Islands to Hawaii, a distance of 1,700 miles, rests on a submarine ridge, the greatest depth between the islands being less than 3,000 fathoms, the distribution and subsequent isolation of the forms on the islands appear to be in accord with the theory of subsidence of the ridge supporting the entire archipelago after wide distribution of the land forms had taken place.

From the affinities and the geographic relations of the several groups of land shells studied our authority deduces the following sequence of events, the beginning of which is placed probably in the Mesozoic, possibly in Eocene time.

I. "The Hawaiian area from northern Hawaii to and probably far beyond Kauai formed one large island which was inhabited by the primitive *Amastrinæ*. This pan-Hawaiian land, whatever its structure, preceded the era of vulcanism which gave their present topography to the islands and probably dated from the Paleozoic." (Plate 75, fig. 1.)

II. "Volcanic activity built up the older masses, subsidence following, Kauai being the first island dismembered from the pan-Hawaiian area." (Plate 75, fig. 2.)

III. "Northern Hawaii was next isolated by formation of the Alenuihala Channel, leaving the large intermediate island, which included the present islands of Oahu, Molokai, Lanai, and Maui." (Plate 75, fig. 3.)

IV. "In the eastern end of this Oahu-Maui island arose certain genera,[14] while another peculiar genera[15] was evolved in the west from undoubted ancesteral stock.

V. "The Oahuan and the Molokai-Lanai-Mauian areas were sundered by subsidence of the Kaiwi Channel." (Plate 75, fig. 4.) On Oahu the molluscan fauna bears out the generally accepted theory of two centers, probably two islands, the western or Waianae and the eastern or Koolau area. In each area certain genera were differentiated, but later, in the later Pliocene or Pleistocene

[13] Tertiary. [14] *Laminella*. [15] *Pterodiscus*.

time, a forested connection was established between the two Oahuan centers of evolution, forming a faunal bridge which admitted of the mingling of the two island faunas. While the land connection endures the forest has, in recent time, become extinct and thus the two centers are again isolated so far as forest-loving snails are concerned.

Turning to the eastern or Molokai-Lanai-Maui region it is Dr. Pilsbry's opinion that the close relationship of their fauna indicate that they formed a single island up to late Pliocene or even Pleistocene time. The formation of the channels between Molokai, Lanai and Maui must be considered as a very recent event since they stand on a platform within the 100 fathom line and their faunas are very closely related.

The investigation of the island fauna and flora as conducted by various observers has brought out facts of evolution that seem in full accord with the dismemberment of the various islands as here described.

In addition to all else the evidence of the wonderfully dissected mountains, the deeply eroded valleys, the submerged coral reefs all tend to bear out the broad conclusion that the group has evolved by the submergence of a single island, and that the isolation of the existing islands, with their peculiar, yet related plants and animals, have been formed as superimposed volcanic remnants on the older and deeply subsided larger land area.

Dr. Sereno Bishop, discussing the geology of Oahu, tentatively offered an estimate of the length of time that must have elapsed since the successive events in the geological history of the island took place. Such estimates of geologic time must of necessity be accepted only as individual guesses and the personal factor taken into account, but they have their value for those less skilled, enabling them to form a rough chronology that the mind can in a measure grasp.

While scientific guesses of this nature are valuable, they are liable in each instance to fall far short of the actual time involved. Dr. Bishop's table places the time of the emergence of the Waianae Range as a volcanic mountain at one million years ago. The emergence of the Koolau Range is placed at eight hundred thousand years ago, and the extinction of the Waianae activity one hundred thousand years thereafter, while the extinction of the Koolau Range is placed five hundred thousand years back in the past. The emergence of Laeloa craters and Rocky Hill are both placed at least seventy-five thousand years ago. The time of the eruption of Punchbowl is given as forty-five thousand years ago: the small Nuuanu craters twenty thousand; Diamond Head fifteen thousand; Kaimuki twelve thousand; the Salt Lake group ten thousand; Tantalus, seven or eight thousand, while the eruption of the Koko Head group, the last of the important tuff-cones to be formed, is given as occurring but a meager five thousand years ago. The author, however, is inclined to attribute a very much greater age to Oahu than that indicated by Dr. Bishop. The foundation for such a belief is based largely on a careful physiographic study of the Waianae Mountains. It seems obvious that the deeply eroded valleys of the Waianae Range were practically completed as they are now before the slight re-elevation of the island

PLATE 31. NUUANU PALI.

1. Nuuanu Pali from the road on the windward side looking back towards Lanihuli peak (2781 feet); on the left of the road is Konahuanui (3105 feet); the road at the Pali is 1214 feet above the sea. The Pali is of great geologic, historic and scenic interest.

brought the ancient reefs above the sea. These elevated reefs contain extinct fossils, probably those of Eocene time. The dawn of the Eocene is generally placed by geologists at four million years ago. How much older then must be the mountain mass in which the valleys of the Waianae region were so deeply carved before the reefs were laid down across the embayments at the mouths of their valley streams?

Artesian Wells.

Reference has been made above to the artesian water supply of the island, and the important geologic facts that the sinking of five hundred or more artesian wells on Oahu has brought to light. The wealth of water, amounting to millions of gallons per hour, now poured out on what was formally in many places semi-arid, and therefore, unproductive land, has been the prime factor in the modern development of the agricultural resources, not only on the island under consideration, but all the islands of the group, where conditions favorable to the development of artesian wells are found.

The erosion of the sloping volcanic lava flows in the mountains offers conditions favorable for storing in the ground much of the excess of the copious precipitation occurring in the higher altitudes. As we have seen, the strata of igneous rock exposed in the mountains are often buried several hundred feet beneath the surface when they reach the costal plain. The water which enters the exposed portion of the more porous strata, especially when the water-bearing strata lie between more impervious strata, tends by gravity to flow as underground water down to the lower levels. Eventually, this underground stream descends to the sea, often several miles distant from the point in the highlands where it was taken into the porous rock or soil.

If the lower ends of the water-bearing strata open into the sea beneath its surface, the fresh water gradually forces its way out at the lower end of the natural conduit, to mingle quietly with the water of the ocean, or, as often occurs about the shore line of the group, to bubble to the surface forming fresh water springs in the ocean.

Owing to the pressure exerted by the sea, the subterranean water moves out much more slowly than the surface water which rushes from the mountains to the sea in the form of rivers. If the pressure of the water in the underground stream is greater than the pressure exerted by the water of the sea, the stream continues to flow into the latter as fresh water. If the pressure of the ocean exceeds that exerted by the underground waters, the two waters commingle, and brackish water occurs in the underground basin. So long as the fresh water level in the underground stream or basin is maintained at a level above sea-level, the water in the underground stream or basin seems to remain free from salt.

An appreciation of the geologic conditions existing in the strata of rock underlying the island, and the need of a more abundant water supply, led to the practical utilization of this great natural resource through the development of artesian wells. The first well was sunk in 1879 by James Campbell on an

island in Pearl Harbor and fresh water was secured at a depth of 240 feet. The natural principle involved in the fresh water spring and especially the spring in the ocean, was turned to practical account. To secure water, wells were driven deep enough into the earth to puncture the more or less impervious strata overlying the water-bearing strata beneath, with the result that owing to the pressure or head on the empounded water, it rose in the well, and in the lower zone about the island often overflowed to form an artificial spring or flowing artesian well. The principle involved in wells which do not overflow is the same as that in those that do; for which reason all deep wells are now called artesian. Wells in which the water is raised to the surface by pumps are liable to become brackish, through excessive pumping, while those which flow naturally seldom show a marked change in the amount of salt carried in their waters.

The water-bearing stratum on Oahu at the sea-shore, is usually found to be between three and four hundred feet below tide level, and is usually a very porous basalt, capped with an overlaying impervious stratum usually of basalt. Wells drilled in the vicinity of Honolulu at an elevation above forty-two feet above the sea have to be pumped. The flowing wells are, as a rule, found at the lower levels. It is of interest to note in this connection that as a rule the shallowest wells are those bored about the ends of radiating lava ridges and that usually their depth increases the nearer they are to the sea-coast. Wells drilled in the middle of valleys are usually deeper than those at either side. All of these facts taken together indicate that the island has been submerged to considerable depth before the subsequent elevation of the raised coral reef on the costal plain about the island, and that the reefs were laid down in submerged valleys that were already deeply eroded before the reefs were formed in them.

In several places, notably at Waianae and Oahu plantations, as well as elsewhere in the group, underground streams have been encountered through horizontal tunnels driven into the mountains, and the underground water supply has been tapped near its head. The tunnel is then extended to the right and left, forming a Y-shaped drain, which brings the water to the surface, far above possible contamination with sea water. Such tunnels are usually driven at altitudes sufficient to admit of distributing the water by gravity over extensive fields well upon the slopes of the mountain. On Maui a daily flow of six million gallons has been secured in this way at an elevation of 2,600 feet. The wonderful Waiahole tunnel on Oahu, built on a modification of this principle, delivers twenty million gallons of water each twenty-four hours.

Economic Products.

Of the economic products, clays are the most important and are found on Oahu, Maui and Hawaii, in many places, in varying amounts. A number of years ago a brick kiln was opened in Nuuanu Valley and brick of fair quality was manufactured. Unfortunately, the attempt was abandoned in a short time.

PLATE 32. COAST SCENES ON OAHU.

1. Kahana Bay. 2. Rabbit Island from Makapuu Point. 3. View across Hanauma Bay from Koko Head toward Makapuu Point. 4. Surf near Waimea Bay.

In 1910 steam bricks were made at Moiliili from pulverized lava by an elaborate process, but, owing to unexpected chemical changes, the bricks were found to be inferior in quality, and the process and product altered after an expensive experiment. Lime manufactured from coral rock has long been a common commodity in the islands, but it has never been considered quite equal to that manufactured from limestone on the mainland. Sandstone of a fair quality occurs at several points about the island. St. Andrew's Cathedral, in Honolulu, is made of sandstone imported from England long before Hawaii became an integral part of the United States. When a few years ago it was decided to enlarge the cathedral, the import duty made it impracticable to go to the same source for more stone. A large part of the United States was unsuccessfully hunted over for a match to the English stone. It was finally found near Barber's Point, about twenty miles from the cathedral site. This local stone is pleasing in color and durable in quality. The hard, compact, dark bluish-grey basalt is much used in building operations whenever cut stone is required. A number of the most substantial structures in the islands are made entirely of cut stone derived from quarries usually opened in the vicinity of the particular structure in which the stone is used.

Much of the softer grade of basalt is used in concrete and in road construction. Beach sand is also used in mortar and to some extent on the roads, and as road dressing. It is usually mixed with coral rock, the whole being rolled together and oiled to form a smooth surface. Sand from beds in the neighborhood of the Waianae Mountains is also used extensively in building operations, but being formed from coral and shells it is undoubtedly inferior in quality when compared with the sharp sand brought from the mainland. Salt is still manufactured on the island by evaporating the sea water in shallow ponds along the sea shore, but the main supply is imported. The use of the loose rough field stone or "moss stone" has recently come much into vogue for foundation and trim work and has added much to the rustic as well as permanent appearance of the bungalow homes, in the building of which it is being extensively used.

This already lengthy chapter on the geology of Oahu would be incomplete without some brief reference to a few of the more interesting, though minor, natural features of the island which are objects of interest to residents and tourists alike. Among these may be mentioned the numerous natural caves formed in the volcanic rock. One at the west end of Judd street, a portion of which was once used as a burial cave, extends back for several hundred feet by a winding, narrow passage. Other burial caves are found above the road at Wailupe Valley, and beyond, while along the sea coast, beyond Koko Head, are caves in which several interesting stone carvings have been found.

Points of Geologic Interest About Oahu.

The coast-line from Koko Head to Makapuu Point is a region of much geologic interest, with spouting horns, olivine crystal beaches, and much coast scenery. The dash of waves against the exposed headlands at Koko Head and

PLATE 33. FORMATIONS OF GEOLOGIC INTEREST ON OAHU.

1. Lava boulders on the grassy plain on the northern slopes of Kaala. 2. Near view of elevated coral reef at Pearl Harbor showing fossil shells. 3. Ford's Island in Pearl Harbor; an elevated coral reef. 4. Coast scenery along the railway on the south side of Kaala. 5. Maunawili showing characteristic "knife-edge" ridges in the Koolau range.

Makapuu Points, are features of an excursion thither that are always much enjoyed, while the picturesque coral bay at Hanauma, and the unmistakable evidence of the nature of the formation of the bay, presents a variety of objects well worthy of a visit.

Along the coast, beyond Diamond Head, at Waialae Bay, are a number of fresh water springs on the edge of the ocean, and at the end of Black Point is a sea cave with a large hole through the roof, from which water and spray spurt thirty or forty feet in the air during rough weather. As has been intimated, the sea slope of Diamond Head is full of geologic interest. Along the beach line sand concretions, caused by organic acids, may be seen in the process of forming about the roots of plants and trees which penetrate the exposed beds. Higher up, in excavations along the line of the road, similar concretions may be found, thousands of years old, in which the roots that formed the center have been completely fossilized.

Pot-holes in the rock along the reef are especially numerous on the shore at this point. Many of them are three feet or more across, and well illustrate this peculiar, rather than important, feature of erosion. The scouring work is accomplished by the grinding action of the sand rock fragments as tools in the hands of the waves. The coral reef between Waikiki and the mouth of Honolulu Harbor is a complete laboratory in reef formation. Seen through a waterglass or a glass bottom boat, the growing, living reef, in connection with the elevated reef farther inland, exhibits the present side by side with the dim past, and shows every phase of this living agent that has played so important a part in the geologic history of the group.

A half day's ramble over the slopes of Punchbowl and down along the nearby Nuuanu Stream will reveal excellent examples to illustrate a hundred points in structural and dynamic geology. The road up Nuuanu Valley, the Pali, and the descent over the floor of the old Pali crater to the sea-shore on the windward side of the island exhibit scores of points of interest to one who cares for geology. The latteral valleys with their gauze-like waterfalls; examples of sub-aërial erosion at the Pali; the splendid dikes displayed in the solid rock by the roadside; the vertical walls of the mighty pit itself; the living reef at Kaneohe; these and a thousand features like them, fill the mind with awe and wonder, and the careful observer is surprised that so much can be crowded into a cross-country ride.

The windward shore of the island at Laie exhibits the combined action of the sea and the wind in piling up dry sand inland into mounds thirty or forty feet in height, and of the effect of the submergence again of such dunes under the sea from whence they originally came and from which they have again been lifted up. At Kahana we have an excellent example of a drowned valley. At Kaliuwaa is a valley of awe-inspiring grandeur; so narrow and deep is it that it forms a dark, narrow passage-way cut into the solid mountain that is shut in with inaccessible vertical walls, nearly a thousand feet in height. Down these basalt walls clear, cold mountain water has cut out smooth channels so re-

markable, in fact that they seem to have been the handiwork of the gods,—and indeed, they were regarded and worshipped as such by the ancient inhabitants.

At Kahuku the elevated coral reef, filled with caves, and the interesting features associated with them, furnish an object entirely worthy of a separate expedition.

The estuaries of the Waimea and the Waialua streams are the main points of interest along the northwest end of the island. Returning to the city by way of Wahiawa, the windward side of Waianae and the long parallel valleys of the lee side of the Koolau Range may be studied to advantage, and the relative age of the two chains observed.

The Salt Lake crater is a feature of much interest since here is formed a lake three-quarters of a mile from the sea, enclosed within a high tuff rim and entirely cut off from the sea, which is more salt than the sea itself. To the student of natural history Salt Lake, with its uplifted and shattered coral reefs, salt-impregnated walls, and other unusual features, is a point of more than ordinary interest. Along the line of the Oahu railway numerous cuts expose the strata of the complex section about the Pearl Lochs and in the neighborhood of the Laeloa craters. Farther on, the lowering walls of Kaala, with its abrupt precipices and narrow buttresses, may be observed from the train as it winds along the coast line. Objects of special interest are the natural bridge and the giant basalt boulders along the coast, and the 'high reef' in the neighborhood of Waianae.

CHAPTER XI.

ISLANDS OF MOLOKAI, LANAI, MAUI AND KAHOOLAWE.

The five islands lying to the southeast of Oahu may all be seen from the decks of the inter-island steamers in making the journey to Hawaii—a journey usually made by travelers in order to visit Madame Pele in her abode in the heart of the living volcano Kilauea.

As a matter of fact, when atmospheric conditions are favorable the outline of the nearest of these islands, namely Molokai, Lanai and Maui, may be plainly seen from the rim of the crater of Diamond Head or Koko Head. Although no one has probably been able to do so, it is not improbable, as asserted by Dr. Titus Munsen Coan, that from the high peak of Kaala, if visual conditions were favorable, the high peaks on all of the inhabited islands could be seen through a telescope.

Molokai.

Since on the actual journey to the volcano the mystical island of Molokai comes first to view, it may be well to know that it is but twenty-three miles from Oahu and that it lies directly between that island and Maui. It extends as a long narrow island almost due east and west for forty miles, but it is

only ten miles in width at its widest part. It is roughly rectangular in form and has an area of two hundred and sixty-one square miles.

Like Oahu, it bears unmistakable evidence of being the result of several periods of volcanic activity, and it, too, is formed by the junction of two volcanic mountains of which the western crater Mauna Loa,[1] an eminence little more than a hill, is far the older. The eastern end of the island is much higher, attaining at Kamakua peak an altitude of 4,958 feet. The highland between the two points mentioned, while less extensive, has been built up in much the same manner as the region between the two groups of mountains on Oahu.

The island from the north presents a more or less vertical face of varying height which rises, as a line of cliffs, usually from a very narrow level plain. From the high backbone of the island in the eastern end, several deep, beautiful valleys, with gaunt finger-like lateral ridges, run down to the sea. The most prominent point along the northern coast is formed by the wedge-shaped peak of Olokui,[2] which has its sea end formed by a wall rising all but perpendicularly from the sea to almost the extreme height of the mountain. The deep balloon-shaped valleys of Wailau and Pelekunu almost surround this point and form its almost inaccessible walls inland. The whole section has been deeply eroded and is one of the most remarkable and picturesque districts of the entire group. The vertical sea cliffs and the great amphitheater-shaped valleys, set, as they are, directly across the path of the northeast trade winds, are almost constantly drenched with heavy tropical rains. Unfortunately this abundant supply of water is still allowed to flow to the sea uncontrolled, while the opposite end of the island, with its thousands of acres of rich, deep-red tillable soil lies parched and barren.

Halawa Valley.

The eastern, and consequently the most remote end of the island, is occupied by smooth, high bluffs topped with a table-land that is cut through by the valley of Halawa. This valley is one of great isolation and primitive beauty. Its purple cliff-like walls terminate abruptly at the head of the gorge in a vertical precipice, over which pour two streams drawn from the rain-soaked uplands. The Halawa waters reach the floor of the valleys by monster leaps, forming Moaula Falls; the other, the Hipuapua stream, forms a single silvery thread from top to bottom of the cliff. The ceaseless tumble and roar of these falls, the delicious freshness of the breeze, the song of the fearless native birds, the abundant vine-swung tropical verdure, the simple friendly hospitality of the natives, the morning and evening rainbows that span the falls, the sweep of the sand-rimmed bay, the tranquil scene of life along the river, the peace, the plenty, the contentment of it all, blends again in memory as I write, as not many years ago it did in reality to form a picture,—a picture of bliss, such as I would paint were I gifted, and call the "Island Vale Avalon"—an earthly paradise within the western sea.

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[1] 1382 feet. [2] 4600 feet.

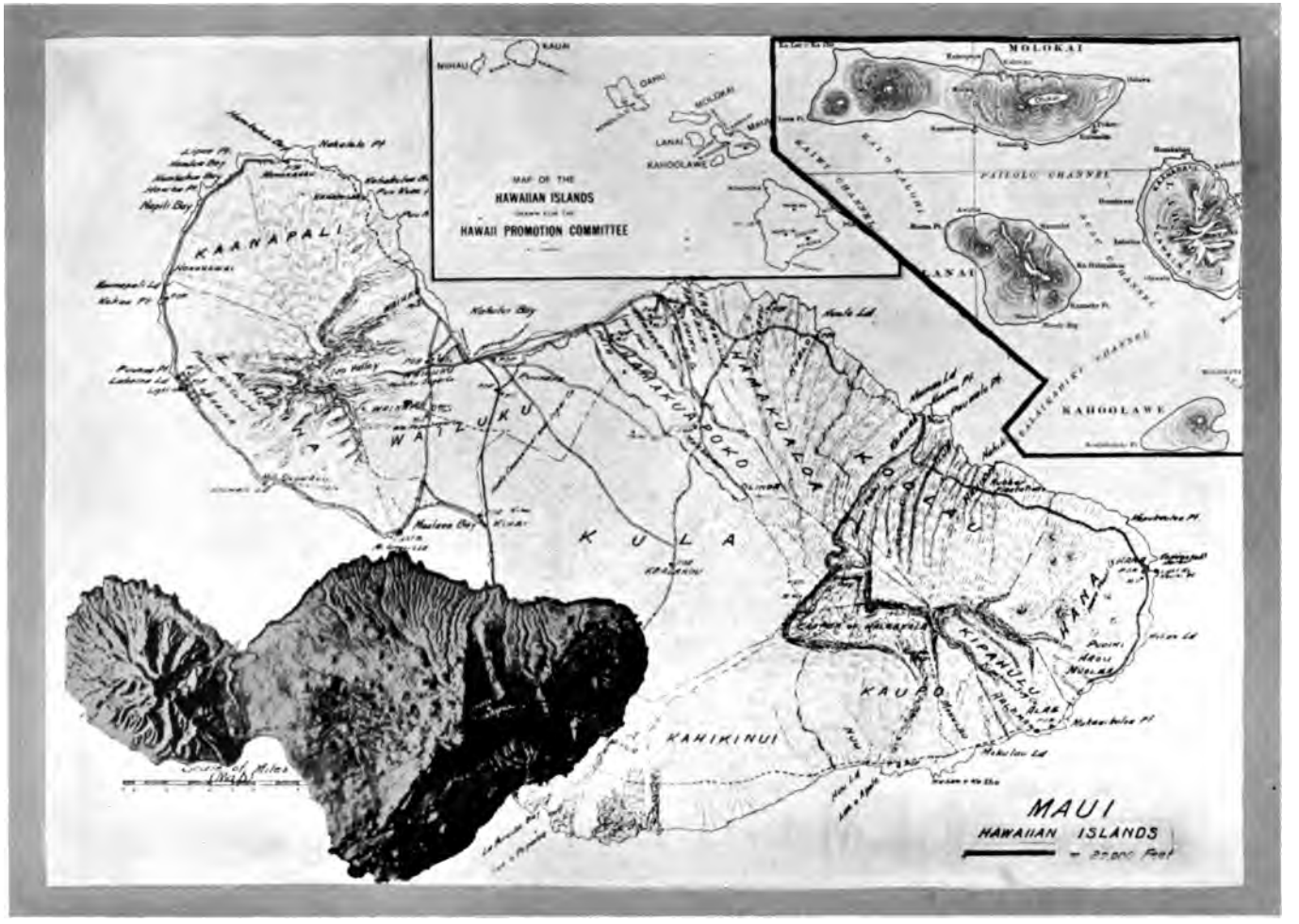

PLATE 34. MAP OF MAUI AND THE ISLANDS OF MOLOKAI, LANAI AND KAHOOLAWE.

The southeastern, and particularly the southern part of the island, is broken by a number of parallel ridges and valleys. As the valleys are many of them but two or three miles in length the streams, which have their source in the cloud-wrapped peaks that form the dividing line of the island, are cool and beautifully clear. In many of these valleys may still be seen the remains of the old orange and breadfruit groves for which Molokai was one time famous. The heads of the valleys often end in almost vertical and deeply eroded precipices. Several of the valleys, as Moanui, have a number of large caves, which were used extensively in olden times as burial caves.

The valley of Mapulehu is the largest valley on the south side of the island. Having steep funnel-shaped sides and being opposite the great rain-soaked valley of Wailau, it is especially subject to torrential rains.

The nearby harbor of Pukoo, well to the eastern end, and the harbor of Kaunakakai, near the center of the island, are the principal ports of call on the southern side of Molokai. They are both formed by openings in the wide coral reef which extends along the greater part of the island.

The Leper Settlement.

Unfortunately the whole of this island of Molokai is known as the "Leper Island." In reality only the low shelf-like promontory of Kalaupapa which jets out into the sea, a distance of three or four miles, at a point about the middle of the island on its northern side, is in any way included in the area set apart by the Territory for the isolation and care of those suffering with this disease.

The settlement forms a colony inhabited by eight hundred to one thousand persons, most of whom are lepers. The colony is completely cut off from the rest of the island by cliffs fifteen hundred or more feet in height, the steep sea-face of which is called Kalawao. The plain or shelf of Kalaupapa is crossed by several lava streams of more recent date than have been found elsewhere on the island. So it is not unlikely that this section, as stated in the legend of Pele previously mentioned, was the last point on Molokai to feel the influence of volcanic fires.

Lanai and Kahoolawe.

Lanai is in plain view from both Molokai and Maui, being only nine miles west from the nearest point of the latter island.

From the vessel as it passes through the channel between the islands it appears as a single volcanic cone, that doubtless, owing to the protection furnished by the nearby-island to windward, has suffered but slight erosion, though its sides are here and there furrowed by small gulches, down one of which there runs a small stream. It has an area of 139 square miles and the principal peak, which is well wooded, is given as 3,400 feet in height. It rises from near the southeastern end and slopes rather gradually to the northwest, where abrupt declivities are found. Steep cliffs also occur along the southwest shore where

PLATE 35. SCENES ON THE WINDWARD SIDE OF MOLOKAI.

1. The sea-shore at Wailau valley, showing the sea end of Olokui mountain (4600 feet) in the distance. 2. "Camp Moomumi," at Kaiehu, showing sub-aerial erosion. 3. A view in the Leper Settlement at Kalawao. 4. The middle falls of Moaula, Halawa valley.

they are often three or four hundred feet in height. It appears that neither Lanai nor Kahoolawe have ever been carefully studied by geologists.

Kahoolawe, the smallest of the inhabited islands, is about twelve miles long and has an area of sixty-nine square miles. Owing to its slight elevation,[3] and the fact that it lies in the lee of Maui, whose high mountains wring the rain-clouds dry, the surface shows but little wash and is almost level. There being no important streams or springs on the island it has never been considered of much value. In consequence it has been given over to a few goats, sheep and cattle that roam over its barren red lands at will. Plans have been considered by the Territorial government, however, which contemplate reforesting the island, as an experiment in conservation, with a view to securing scientific data on the increasing and storing of water through the agency of plant growth.

Like Lanai, the island of Kahoolawe has high, steep sea cliffs on the lee shore. Enough of the underlying strata is exposed to foster the belief that neither of these small islands was ever more closely connected with each other or with the nearby and larger island of Maui than they are now unless it was by their normal slopes, now hidden beneath the sea. The larger island of Maui is separated from the smaller of the two islands by seven miles of placid water known as the Alalakeiki channel which, together with the Auau channel between Lanai and Maui, forms the Maui channel; a waterway which no doubt has been formed by the subsidence of all three islands just mentioned.

Maui, the Valley Isle.

It is the custom to regard Molokai, Lanai, Kahoolawe and Maui as forming a natural group of islands, there being about the same distance between the nearest points on the neighboring islands of Molokai and Oahu[4] in the northwest, that there is between the nearest points of Maui and Hawaii[5] at the southeast end of the central cluster of islands, the combined area of which is placed at 7,289 square miles. Maui is the largest island in the middle group and is the second largest in size of the inhabited islands. However, it is considerably less than one-fifth the size of Hawaii, which boasts of its area of 4,015 square miles.

To the mere traveler Maui is but a synonym for the name of the great extinct crater which forms one of the chief objective points of his round-the-world journey. But to the geologist the splendid double island, aptly named the Valley Isle, is no less interesting in its topography and history than Kauai or Oahu are.

Like Molokai and Oahu, it has been produced from two distinct centers of volcanic activity. West Maui with its highest peak[6] corresponds in age with the western group of mountains on Oahu. As on Oahu, the advanced disintegration, shown by the deep wonderful valleys dissected into its mass, makes it unmistakably the older end of the island. In fact it has every evidence of being as old as Kauai, the Waianae Range on Oahu, the western end of Molokai, or the Kohala mountains on Hawaii.

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[3] 1472 feet. [4] 23 miles. [5] 26 miles. [6] Puu Kukui, 5788 feet.

Iao Valley.

As has been the case on the other islands, this volcanic pile has suffered its deepest erosion on the northeast flank. Exposed to the trade winds, the great awe-inspiring valley of Iao, with its head a vast amphitheater in the very heart of the mountain, has been so wonderfully eroded that it is indeed difficult to feel it has been formed solely by the chisel of the elements.

Rising on every hand about "The Needle," an isolated, nearly inaccessible pinnacle, standing hundreds of feet above the floor of the valley—are almost vertical verdure-covered walls of basalt. They rise abruptly for more than four thousand feet. Over and about the top of the highest peaks cluster and frolic the down-like clouds that so often, without apparent provocation, gather into a lowering pall from which pours torrents of cold, pelting rain. Within an hour their waters will flood and choke the babbling gorge stream, until it rushes down to the sea in an irresistible torrent.

Few are the visitors who have seen the grandeur of Iao who are not willing to compare it favorably with the more famous valley of the Yosemite. But those who have mastered the difficulty of the ascent and who have once looked down from the summit of Puu Kukui into the head of Iao Valley, and the equally wonderful valleys of Waihee and Olowalu, are unstinted in their praise of the wild scenery that stretches away from their feet in all directions—to the ocean, to Haleakala, and to the snow-capped mountains of Hawaii. Those travelers who can take the circumstances that surround each into account and compare the grandeur of the Valley Isle with the grandeur of the Yosemite never fail to rearrange the list of America's great natural wonders in a way most complimentary to this island wonder, which, unfortunately, too few have as yet been privileged to visit.

The summit of Puu Kukui is made up of an extensive bog which, as a great mountain reservoir, receives and stores the water that flows down the lee or Lahaina side of the mountain. As a matter of fact no fewer than eight cañons radiate in all directions from the central portion of west Maui, at least five of them being notable for their size. The whole summit of this western end of the island is copiously supplied with water. It is therefore well wooded, although the lower slopes, especially on the southwestern side, are dry and barren. Along the shore the costal plain is composed of rich red soil washed from the mountains. When artificially watered and under cultivation it is most productive.

In its outline the island of Maui has often been compared to the head and bust of a woman. West Maui, the head, with the face looking to the southwest; the lowland joining the portion just described to the larger eastern end of the island, forms the neck, with Kahului Bay at the back of the neck and Maalaea Bay forming the hollow beneath the chin.

HALEAKALA.

The giant crater of Haleakala, easily the largest extinct crater in the world, rises as a shoulder from the center of the portion forming the bust of our figure, to the sublime height of 10,032 feet. Besides being the feature of the topography of Maui, since it covers an area six times as large as west Maui, it furnishes to the world a single striking, clean-cut example of the awful power in nature which can rock continents on their foundations and lift up islands in the midst of the sea, until their tops are lost above the clouds.

The low plain forming the neck or isthmus between the eastern and western extremities of the island is almost level and is about six miles in length, by seven or eight in width, at the narrowest part. There seems every reason to believe that this portion of the island was at one time a waterway, and that then the older and the newer ends of the island were separate. Later this shallow channel was filled by flows from Haleakala which have been added to by wash from the highlands. The sand dunes near Wailuku are two hundred feet high and contain only fragments of coral and sea shells in the form of sand particles that point to their origin, while the sand hills nearer the shore and elsewhere are undoubtedly the products of the wind. Wind-blown or æolian calcarious sand has had much to do with the building up of the low land deposits; the central part of the neck being only 156 feet above the sea. In the sand hills along the shore in this portion of Maui, as elsewhere in similar situations in the group, numerous calcarious concretions and fossil land shells are found.

The trip to Maui is in many respects the most interesting one in the islands to the traveler. Naturally Haleakala[7] is the chief object of interest to the tourist and scientist and its ascent is often made as a side trip on the journey to or from the active craters on Hawaii. In plan east Maui, which is formed solely by Haleakala, is roughly triangular in outline, with the crater lying well towards its eastern angle. The windward side of the dome being well watered is furrowed by numerous cañons and gorges. Along the side exposed to the weather there are sixty or more eroded cañons, most of them carrying fair-sized streams, in a distance of half as many miles. While abundant rains fall on the eastern or Hana end of the island, the cañons are wanting, owing perhaps to the resistant nature of the more recent lava flows in that region.

From Hana to Kaupo on the south side of the island, the slopes are cut up into numerous gorges, many of them with streams. The ravines here have long been celebrated for their riot of tropical verdure, but as the trail from Kipahulu

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[7] The Hawaiian name for this mountain, meaning the "house of the sun," doubtless finds its origin in an interesting and very ancient folk-tale of the people. According to the legend it was to Haleakala that Maui,—the adventurous son of Hina—went to capture and tame the sun. The object of the exploit was to discipline the sun in its course and make it go more slowly in order to give time for the drying of the bark cloth or tapa which his mother made. We are told he was successful in capturing the sun by ingeniously snaring its rays as they rose one by one over the top of the mountain. When at last sixteen of its longest rays had been captured the sun, begging for mercy, was hauled down to earth by Maui, who only permitted it to continue on its course when an agreement had been made that the sun should go more slowly ever after and that in certain seasons the days should be longer than in others. The Rev. Mr. Forbes, the Hawaiian Missionary, who first published the legend, asserts that it was this adventure that gave the name to the mountain which should properly be called Alele-ka-la (sun snarer) and not by the more poetical name Haleakala, now in general use.

PLATE 36. VARIOUS VIEWS ON MOLOKAI.

1. Upper falls of Moaula. 2. Sea-beach at Halawa valley, showing the sacred kamani grove to the left. 3. Hipuapua Falls. 4. Abandoned cave dwelling in sandstone cliff at Moomumi. 5. Exposed fossil root-casts, in dunes on Molokai. 6. The great temple [heiau] Iliiliopai, Mapulehu valley, from slopes above.

on leads up and down over the points of the ridges the road is a difficult and tedious one to travel. The absence of important cañons on the western side of Haleakala seems to be due to the fact that the rain clouds are relieved of their burden on the opposite slopes of the mountain, so that the two sides when compared furnish interesting examples of the effect of wet and dry climate on the same mountain.

The Great Crater Described.

The trip to the summit of the mountain is usually, though not always, made from Paia, the terminus of the Kahului railroad. Paia is situated on the northwestern slope and can be easily reached from most of the landings on both Maalaea and Kahului bays. As no better conception of the great crater and this portion of the island can be formed than that gained from making the ascent, it is proposed to follow the usual route, which, from Paia, leads to Idlewild [8] and on the way to the summit, a distance of about twenty-two miles.

The outer slopes of the crater on all sides are quite irregular, ranging between eight and ten degrees, but the slope is a trifle steeper on the northeastern side. This makes the ascent an easy uphill climb that it most deceiving. The lower western slope of the mountain has been graphically described as resembling a whole township diversified with farms and woods, valleys and hills, resting on its elbows, so to speak, and looking out over the broad Pacific. From the base of the mountain one can look up to the cloud-line and often get a glimpse of the summit through an occasional rift in the clouds.

At Idlewild [9] the traveler leaves his wheeled conveyance and continues the ascent for a distance of eight miles on horseback. For six miles the trail leads by an easy, gradual climb through grassy pasture land, where the skylarks, stimulated by the fresh, cool air of the mountain side, often mount skywards. carrying their song far into the clouds.

From the cloud-belt on to the summit the trail becomes rougher and steeper. The grass and trees of the lower reaches give way to low, scrubby bushes. Entering the clouds the soft white fog usually obscures everything above and below, but in less than an hour's climbing the rough, jagged outline of the summit appears, floating on a sea of clouds as the traveler emerges into the sunshine again. Often the world below is completely hidden from view; more often, however, the blue Pacific may be seen in the distance, apparently rising like the inner side of a vast blue bowl until it joins, in some mysterious way, with the edge of the bright blue dome that overtops everything, even this high mountain.

From the favorable places, at this great height, much of the outline of the island may be seen, spread out like a great colored map lying on the lap of the mountain. West Maui appears usually above the clouds as the detached summit of another island mountain.

As the trail ascends it winds about the base of more than one sizable crater,

[8] Olinda. [9] Elevation 4500 feet.

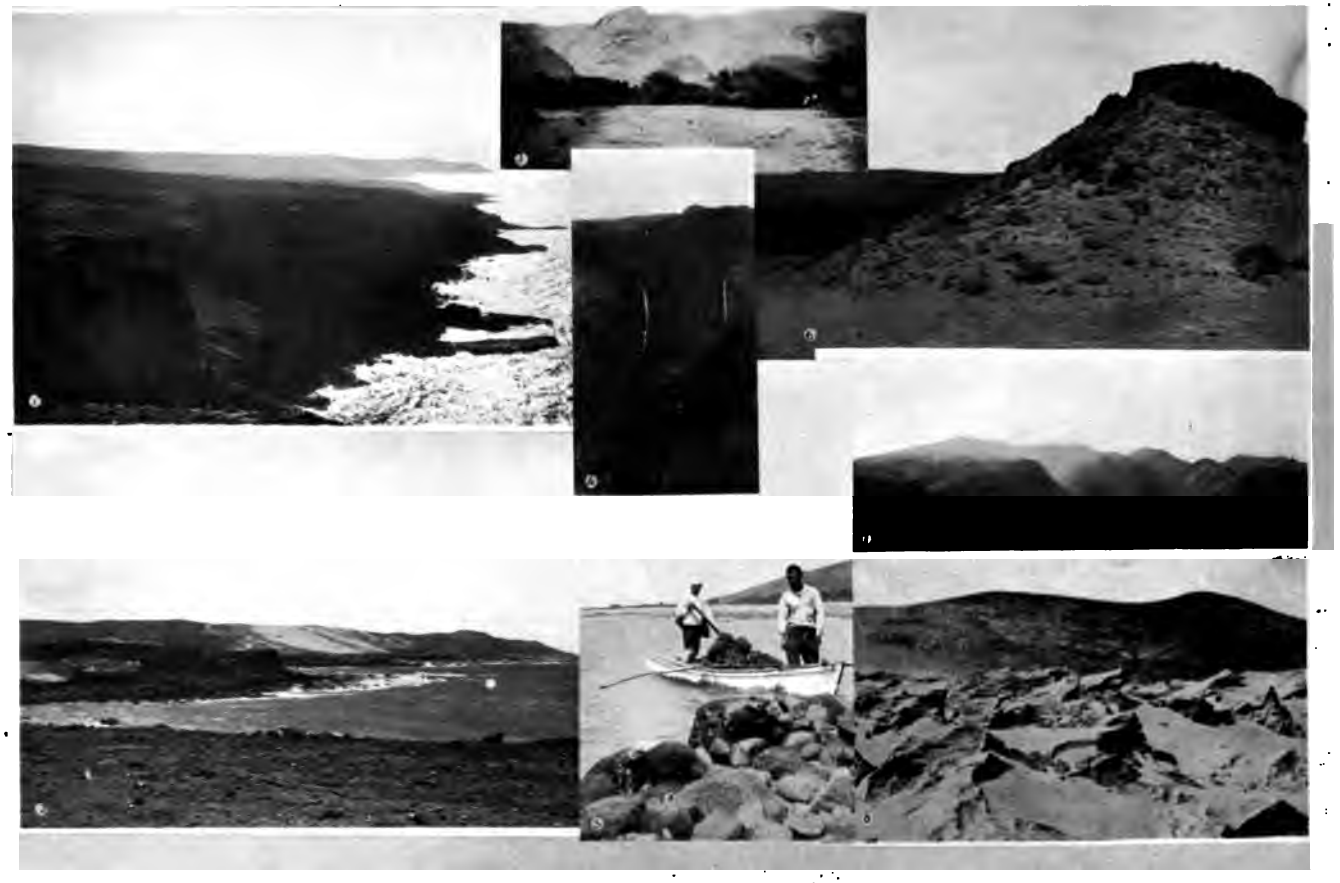

PLATE 37. SCENES ON AND ABOUT MOLOKAI.

1. Coast along the north-west end. 2. General view of the dune area at Moomumi. 3. Mountains back of Kamalo. 4. Falls at the head of Halawa valley. 5. Gathering coral, Molokai reef. 6. Erosion of a solidified dune, Moomumi. 7. Mountains back of Kaluaaha. 8. Erosion of sandstone by the wind and waves.

but in comparison these seem to be mere pimples on the back of the gigantic Haleakala. Taking the entire western slope into consideration there are two dozen of these craters. Most of them appear to be very ancient but show no evidence of ever having been points of eruptive flow, though on the west coast near the shore there are several streams of very fresh-looking lava that may be traced to some of them.

All the route to the summit is exceedingly interesting and instructive to one with an interest in geology, but to the ordinary tourist the ascent seems a trifle monotonous after the first few miles of travel. The surface of the mountain is everywhere covered with quantities of broken red rock and resembles the region about Kaimuki on Oahu. On the lower slopes the lava beds, which compose the foundation of the mountain when exposed, show their texture to be very solid and apparently very resistant to the ordinary forms of erosion.

After passing the mountain house [10] the first view of the crater is obtained. On arriving at last at the very edge of the caldera the immense size of the yawning gulf does not readily take hold on the imagination. It is only by comparison and after its dimensions have been reduced to miles and acres and its altitude to feet that the sublime magnitude of the scene is appreciated.

One must think of this stretch of mountain scenery not as a mere view to be admired but rather as a burned-out boiling pot twenty miles in circumference, that has an area of twelve thousand one hundred and sixty acres—five times that of Kilauea. Measure with the eye its extreme length from point to point [11] and its extreme width [12] and compare it with the largest city you have ever seen! See if you can realize that the island of Manhattan with all the teeming life of New York City could be comfortably placed in this mighty chasm and buried more than a quarter of a mile deep! Grasp the fact that the floor of the crater, at its lowest point,[13] is two thousand nine hundred and fifty-two feet below the highest point on the rim and that the point, Pukaoaa, or Pendulum Peak [14] is 10,032 feet above the level of the sea.

The sixteen mounds on the floor of the crater towards the south end are not mole hills, but craters, the highest of which [15] rises nine hundred feet from its base, while none of them are less than four hundred feet in height. Compare any one of these with Punchbowl or Diamond Head on Oahu and remember that they are but the last parting touch laid on as the titanic fires that gave birth to all the grandeur and desolation that surrounds them, died out, retiring into the bowels of the earth hundreds, possibly thousands, of years ago, perhaps never to appear on Maui again.

One of the most impressive sights in the entire group is that frequently to be witnessed on the edge of this yawning gulf as the sun sinks into the western ocean. Set as it were between heaven and hell, the change in the atmospheric conditions on this great mountain summit are most rapid and pronounced. As the sun drops in the sky and the chill of night comes on, the clouds that

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[10] 9,287 feet elevation. [11] 7.48 miles. [12] 2.37 miles. [13] The cave. [14] White Hill or Pakaoao. [15] Kalua Ka Oo.

all day drowsily float about the slopes of the mountain suddenly become restless and crowd and jostle and mill about one another like frightened animals. At the proper moment, as at a signal from some shepherd of the winds that guides and protects them in the pasture of the heavens, they recognize and peacefully follow their leader. One by one, in dozens and in droves they work around the slopes of the mountain to where the great gap in the crater wall, like the gate to a sheep fold, is opened wide, ready to receive them from the pasture out on the mountain side into the shelter and protection of the crater fold,—the very heart of the mountain that nourishes them.

As darkness gathers the last stragglers, those that have wandered farthest from the fold, hurry in to join their fellows until the floor of the crater is hidden from view by the fleecy multitude. In the shelter of the crater wall they settle down for the night knowing, perhaps, that e're long the Southern Cross will climb into the cold clear sky to share with the great Polar star the vigils of the night. The first ray of light that gilds the mountain is the signal from the shepherd, and at once the crater fold is active; round and round these cloud-sheep go, impatient to be up and away. At the proper moment they again form in line behind the one appointed to lead the way out through the gap, and before long are away for a day's frolic in their favorite haunts on the mountain side.

Should the traveler fail to witness the gathering of the clouds by night or their parting in the morning, the chances are that, as a substitute, he will witness the most gorgeous sunrise to be seen anywhere; or perhaps, if the weather is fine, the gleaming snow-capped peaks of Mauna Kea and Mauna Loa on Hawaii will loom up to the south more than a hundred miles away.

But to return to the scene near at hand. The crater is not regular in its outline but appears as two or more associated craters fused into one. However, one gets but an imperfect conception of the shape or extent of the crater from a single viewpoint on the brink. The zigzag elbow-shaped pit has its highest point formed by one of the three cinder cones at the southwest angle of the crater. The wall at the north end is split down to its bottom to form the yawning Koolau gap with its towering walls. This gap extends to the sea under the name of the Kanae valley. At the opposite or southern end of the crater is a similar break, the famous Kaupo Gap. It descends abruptly as a gorge-like valley to the sea. It is completely floored with a hard lava stream with occasional clinker beds. About half way down the mountain this stream emerges from its gorge and spreads over the surface, forming a fan-shaped delta, extending to the sea. These gaps are among the more striking features of Haleakala and are looked upon by some as offering all the evidence necessary to prove that the great crater, as it now exists, was formed by a mighty fault which split the mountain from north to south, freeing the extreme eastern[16] portion of the island from the opposite side. The gaps down which the lava subsequently flowed are thus but extensions of the crack or fault. As such they had their part in preventing the crater from filling up with lava as it might

[16] Hana.

PLATE 38. THE SUMMIT OF HALEAKALA.

1. The old mountain house at the summit. 2. General view inside the great crater showing a few of the many craters on its floor.

otherwise have done—a course well illustrated by the summit crater on Mauna Kea.

The Floor of the Crater.

The floor of the crater is well covered with cinders, scoria and sand, its surface being relieved by the cones previously mentioned. From these craters the loose material forming them, and that covering the floor of the great crater enclosing them, was erupted. The light, loose material in the crater has a reddish tinge often varied with black, grey, yellowish-brown and red and shows no mark of its exact age. Toward the extreme eastern end there is an old pahoehoe flow, and high up on the eastern wall two flows of aa have broken forth. Coursing down the side wall, they have pushed their way some distance out over the floor of the crater.

Although the walls of the crater are steep it is possible to descend them almost anywhere. The descent is made easier on account of the sand and cinders that have been heaped up at the foot of the cliffs on all sides. The floor and inner walls of the crater are of great interest to geologists and will well repay a visit. For the tourist, the "bottomless pit," a remarkable blow-hole; Pele's Pig-pen, a small partly-filled crater; the Chimney; the Crystal Cave; and the chain of four craters known as the Natural Bridge, lying along a crack in the floor of the crater, are natural objects well worth inspection at first hand, and interesting enough to tempt many to make the scramble down into the crater.

The summit of the mountain and its crater is a barren waste only relieved here and there by a few plants, among them the remarkable plant known as the silver sword, which is elsewhere described.

The History of Haleakala.

Geologists agree that the history of Haleakala is a complicated one in which the formation of the mountain by the usual processes of summit eruptions and surface flows have played dominant parts through long ages. The fracture of the mountain that opened the great discharge ways at either end of the crater must have occurred as the mountain was nearing completion. The simultaneous discharge of lava by both of these great openings in the crater wall is proven by the similarity of the lava found in the gaps themselves and in the floor of the crater from end to end.

As the life of the mountain as a living volcano neared its close, it appears that the convulsions which split the pile to its foundation brought about the appreciable sinking of the extreme eastern portion of the dome. The final flows from the gaps at either end of the crater reunited the fracture in the foundation, filled the subterranean chambers formed by earlier flows, and left the crater a solid mountain with its interior completely filled with the rock material that makes up its huge bulk. The expiring fires, through minor fissures in the last-formed crater floor, threw up the numerous cinder cones scattered over it.

The Last Eruption on Maui.

The date of the last summit eruption is unknown even tc Hawaiian genealogical and traditional history. There is a fairly authentic statement, however, that the last eruption on Maui occurred about two hundred years ago as a lateral eruption. It emerged at an elevation of about four hundred feet above the sea on the southwest slope of the mountain in the region marked by a line of craters extending from the summit to the sea. In its course it flowed over a Hawaiian stone fence, indicating the historic relation between the extinction of the volcanic fires and the mountain's occupation by human inhabitants.

When the fires finally died down they apparently were completely extinguished on the island. No steam jets or warm springs, no mineral springs nor solfataras remain behind to bridge the closing period of activity with the present, and there have been no signs in historic times to indicate that the island of Maui will ever witness active eruptions again.

CHAPTER XII.

ISLAND OF HAWAII.

Size and Position of Hawaii.

The last island to the southeast of Oahu and the one which gives the name to the group, is the island of Hawaii. It is not only the largest, but is also the most important island of the chain. It is approximately triangular in form with its greatest length [1] from north to south. It has an area of 4,015 square miles, which is a trifle less than the area of the state of Connecticut. Enclosed within its 297 miles of coast line, is five-eighths the area of the whole group. Of such an area only a few of the many important facts touching its geography, topography, geology and vulcanology can be referred to in the briefest manner in a single chapter.

Its coast line is interesting and varied, but the more important points geographically are the capes at the chief angles and the shallow bays at intervals along the coast which are volcanic in origin, being formed in each case by the irregularities in the flow of lava into the sea. Its area is made up of the summits of five mountains, one of which [2] attains the height of 13,825 feet above sea level, and claims the distinction of being the highest peak in the islands and the highest point in the Pacific. In general Hawaii's topography is formed by the simple joining of its five main peaks by their gentle slopes in such a manner as to produce the simple outline of the island. There are few rivers of consequence except on the northeast or windward side.

On all sides the slopes of its great mountains are scarred by the courses of the broad lava streams that, at various times, have plowed their way from near the summits of the central peaks. Often, even in recent times, these streams

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[1] 93 miles. [2] Mauna Kea.

HAWAII
HAWAIIAN ISLANDS
KOHALA
MAUNA KEA
HILO
MAUNA LOA
KAU
PUNA
KONA
HILO
KEAAU
KEAUHOU
PAHALA
NAALEHU
KAILUA
KEALAKEKUA
KAWAIHAE
KAMUELA
WAIMEA
HONOKAA
PAAUILO
HAMAKUA
KAPAAU
HONOMU
PAPAIKOU
WAIAKEA
OLAA
KURTISTOWN
GLENWOOD
KAPAPALA
KAPAPALA
KAHUKU
KAHUKU
KAHUKU

have found their way down to the sea-shore, leaving blackened, desolate tracks behind that nature and the lapse of time have done little to repair.

The Kohala Range.

While the island, owing to its active volcanoes, is considered as the youngest island of the group there is little doubt but that the Kohala Range, forming the northwest point, is the remains of a very old, perhaps among the oldest of the Hawaiian volcanoes.

The slopes are deeply cut and the work of degradation has left deep cañons and enormous cliffs as the evidence of great antiquity. This portion of Hawaii is somewhat separated from the younger group of craters, being isolated from its neighbors, Hualalai and Mauna Kea, by the tableland of Waimea.[3] The summit of the Kohala Mountains[4] is made up of a series of cinder cones and, owing to the great rainfall, is a heavily wooded bog like that on the top of Kaala on Oahu, and Waialeale on Kauai. All of the windward slope of the range is much eroded, and is densely wooded.

From the coast the range appears as a series of deep cañon-like valleys that end three or four miles inland with vertical cliffs from 1,500 to 2,000 feet in height. Among the more noteworthy and scenic of these are the valleys of Waipio and Waimanu. The walls of these stream basins, especially after a heavy rain, are a veritable display of waterfalls, some of them pouring down in a sheer drop for 1,500 feet. So vast and profound are these gorges, and so steep are their sea faces, that their formation seems due to some great fault along the sea cliffs, which caused a portion of the mountain to drop out of sight beneath the waves, leaving great lateral fractures to form into valleys through the action of the elements; though it is quite probable they may prove, on further study, to be the remains of valleys formed before the subsidence of the Kohala mountains.

On the opposite side of the mountain, along the shore from Kawaihae Bay around to the north point[5] of Hawaii, the surface of the island is more regular, though at several places lava streams have issued in ancient times from craters higher up and flowed down to the coast. The road from Waimea to Kohala is at an elevation of fifteen hundred feet or more and leads past several of the cones that dot this region. Some of these are perfect cones four or five hundred feet in height; others are much disintegrated and appear as little more than rounded hills.

The soil of the district is a rich, red, ochreous earth and when well watered is very fertile. It was at Kohala that one of the early and successful plantations was established.

Mauna Kea.

The principal part of the northeast coast of Hawaii is formed by Mauna Kea, which occupies more than half of the northern part of the island. Although

[3] 2670 feet. [4] 5489 feet. [5] Upolu.

PLATE 40. VIEW OF THE WINDWARD COAST OF HAWAII.

1. Characteristic shore line in Hamakua. 2. Cocoanut Island, Hilo Bay. 3. A typical Hawaiian gulch. 4. The natural arch at Onomea.

it is an extinct volcano it is of especial interest and has the distinction of being the highest island mountain in the world, though it is by no means so bulky and imposing as its neighbor Mauna Loa. The Mauna Loa summit is only 150 feet below that of Mauna Kea, and were it not for the cinder cones that cap the summit of the latter the former would be given its proper rank as first among the island mountains of the world.

Mauna Kea has probably been extinct for centuries, but not long enough for the abundant rains which fall on its northeast side to furrow out its slopes more than half way to its summit. Its lower slopes, however, are cut up into many gulches from which the water pours into the ocean from the hanging valleys that notch the vertical sea cliffs all along the Hamakua and Hilo coast.

As is usual with the higher mountains of the group, its southwestern slopes show little signs of erosion, and owing to the comparatively small amount of rain that reaches that side it is almost bare of vegetation. The effect of rainfall may be very clearly seen here, since the windward side has the upper limit of its important vegetation at about ten thousand feet, whereas the dry or southern side has little if any vegetation on its slopes above seven thousand feet.

The top of this mountain, like its neighbor Mauna Loa, is often covered with snow that sometimes forms a glistening white cap as far down as two thousand feet or more from the summit. Unlike Mauna Loa its sky line does not end in a single crater. Its elliptical summit is rather thickly sprinkled with a number of cinder cones; about two dozen being above the 12,500-feet contour line. One of these is occupied by a pond[6] forty feet deep and several acres in extent. The pond is filled with water from the melting snow and on several occasions has been found frozen over solid enough to bear the weight of adventurous mountaineers.

Lower down there are a large number of small cones, as many as seventy-five having been enumerated above the 6,500-foot contour on the survey maps, while the outline of the lower flanks of the mountain is also relieved by them. At about twelve thousand feet elevation there still remains the evidence of an old adze quarry[7] from which the old-time Hawaiians secured much of the solid clinkstone used by them in the manufacture of their stone implements.

The Ascent of Mauna Kea.

Mauna Kea may be ascended from Waimea by way of the Humuula sheep station on the southwest, and on the east side from Hilo by way of Shipman's ranch. Horses may be ridden to the summit plateau. The rise of the mountain is gradual, averaging about four hundred feet elevation to the mile. From the plateau at the summit a splendid view of the adjacent mountain is secured. To the southwest the outline of the summit crater of Mauna Loa can be traced, the summits being about twenty-five miles apart. The northerly slope of Mauna Loa is much disfigured by recent eruptions, the flows of 1845, 1852,

[6] Lake Waiau. [7] Keanakakoi.

1855, 1880 and 1890 all being plainly visible from the summit of Mauna Kea—the white mountain.

Dr. C. H. Hitchcock, who made the ascent in 1885, writing of the recent flows visible on Mauan Loa says: "They are narrow and tortuous near their sources, spreading out low down into black extensive areas, almost coalescing. Besides these, others of prehistoric age can be traced and nowhere can one be more impressed by the fact that the mountain has been built up by intermittent lava flows, and can appreciate the certainty that millions of years were required to construct this eminence." When not covered with snow the surface of the plateau of Mauna Kea is described as a desolate gravelly plain on which occur five or six species of plants resembling those of the colder climates of high altitudes. As reported by Professor MacCaughey, the lake at the summit, though very cold throughout the year, supports a very luxuriant growth of green algæ.

Hualalai.

Along the western coast of the island to the southwest of Mauna Kea, and about equal in distance from Kohala to the north and Mauna Loa to the south, is Hualalai. It is a much smaller mountain than Mauna Kea, but otherwise resembles it in its general outlines and in having no characteristic summit crater. It is 8,269 feet high and has its base entirely within the Kona district. Its lower base slopes quite gradually, but the upper part of the mountain is much steeper and is rough and difficult of ascent. The north side of the mountain appears quite bare, but the opposite side is well wooded. Its slopes are dotted with many cinder cones—hundreds perhaps, which increase in size and number toward the top.

The few naturalists who have ascended this lawless mountain have found its summit covered with crater bowls,[8] cinder cones and pit craters. Some of the craters have gravel bottoms, while others are formed with hard basalt floors. One of the features of the summit is the "bottomless pit"—a blow hole twenty feet in diameter and 400 feet deep.

The Eruption of 1801.

The last eruption of Hualalai is placed at about 1801. It occurred from an opening on the sea or western side of the mountain. From there the lava descended to the sea in a wedge-shaped stream. The flow was a very liquid one and is said to have traveled a distance of fifteen miles in two or three hours. This flow is believed to have marked the extinction of the volcanic fires beneath the mountain.

An early missionary, the Rev. William Ellis, gathered an account of the eruption from eye witnesses, who were living in 1823, about twenty years after the flow. His account states: "Stone walls, trees and houses all gave way before it, even large masses of rock of hard ancient lava, when surrounded by the fiery stream, split into small fragments and, falling into the burning mass, appeared to melt again as borne by it down the mountain side. Offerings were presented

[8] One of them 800 feet in diameter.

and many hogs thrown alive into the stream to appease the anger of the gods, by whom they supposed it was directed, to stop its devastating course. All seemed unavailing, until one day the king Kamehameha went, attended by a large retinue of chiefs and priests, and, as the most valuable offering he could make, cut off a part of his own hair, which was always considered sacred, and threw it into the torrent. A day or two after the lava ceased to flow; the gods, it was thought, were satisfied."

The Mountain of Puu Waawaa.

On the north slope of Hualalai near its base and in plain view from Kawaihae Bay, is a curious fluted mountain called Puu Waawaa.[9] Numerous shallow ravines radiate from its summit in all directions, clearly the work of rain. Its curious form is of interest to the traveler, but it has been seldom visited by scientists. It remained for Dr. Whitman Cross of the U. S. Geological Survey to discover that the terrace bench at this point contains lavas rich in alkali feldspar, a discovery of importance since formally only basalt and allied rocks have been credited to the islands. The position of these alkali lavas indicate the possibility of an older and extensive eruption forming an island beneath the later basaltic flows of the great mountains of Hawaii that rest upon the older island base.

Mauna Loa.

An examination of the map of Hawaii will show Mauna Loa, the second largest active island volcano in the world, as occupying the entire southern half of the island, being seventy-four by fifty-three miles in its base dimensions at sea level. It terminates in the great active crater, Mokuaweoweo, which is three and three-quarters miles[10] long by one and three-quarters miles in width, with an area of 3.70 miles.[11] This splendid caldera, the most perfectly formed crater in the islands. is enclosed in walls from five hundred to one thousand feet in height. Like its neighbor on the north, the top of Mauna Loa is a plateau, its highest point being 13,675 feet above the sea, or more than 30,000 feet above the floor of the ocean about the group. From the central point the slopes of the mountain radiate at a fairly uniform angle in all directions.

Rough lava flows of aa and pahoehoe which overlap each other extend from near the summit of the sea-shore like the spokes in a wagon wheel. They show clearly the way the vast mountain has been slowly built up through countless ages. Owing to the altitude and the amount of rough lava on its slopes the ascent of Mauna Loa is an exceedingly difficult, and, in many respects, a dangerous task. The first recorded ascent was that made by the famous traveler, John Ledyard, in 1779, who visited Hawaii as a member of Captain Cook's party on his last voyage. He made fairly accurate, though necessarily fragmentary, record of the general features of the mountain.

The second attempt to explore Mauna Loa was at the time of Vancouver's

[9] 3824 feet elevation. [10] Dimensions in feet: 19,500 by 9,200 feet. [11] 2370 acres.

PLATE 41. SHORE AND MOUNTAIN VIEWS OF HAWAII.

1. General view of the summit of Mauna Kea. 2. Waipio Valley showing its wonderful waterfall. 3. Near view of the summit of Mauna Kea. 4. The landing at Laupahoehoe.

visit. An account of the ascent made at that time was recorded in Archibald Menzie's journal, in 1794, and remained unpublished until brought to light through the researches of Prof. Hitchcock and printed for the first time in Thrum's Annual for 1908. Mr. Menzie calculated the height of the mountain by use of the barometer without corrections for the variations in temperature [12] and made it but forty-one feet less than the present accepted altitude. From the time of Menzie's ascent to the present the mountain has been under almost constant observation, and many parties of competent observers have attained the summit. Its extensive and interesting history has been fully recorded and compiled in two elaborate monographs, one by Prof. Hitchcock and the other by Dr. Brigham, both appearing in 1909. To these works the reader is referred for detailed accounts of the long series of eruptions, the bare enumeration of which are almost beyond the scope of this chapter.

History of the Eruptions of Mauna Loa.

However, it is of interest to know that eruptions were reported on Mauna Loa in 1780 and again in 1803; the first fully recorded eruption occurred in 1832, and in June of that year Mauna Loa is reported, by the Rev. Joseph Goodrich, to have ejected lava from several places in the side of the mountain, presumably some little distance below the summit. From that time until the last eruptive flow [13] the lava has always issued from the weak places in the side of the mountain, though the caldera at the summit has on numerous occasions become active, forming a lake of lava without flows taking place.

Of the fifteen eruptions resulting in flows that have occurred on Hawaii within the last one hundred years, twelve have had Mauna Loa as their source. The eruption of 1843 was presaged by activity in the crater of Mokuaweoweo but after a few hours the fire died down in the crater and reappeared on January 10, 1843, in two places on the northeastern shoulder of the mountain, at about 11,000 feet elevation; from these, lava ran in a broad sheet down the side of the mountain for about sixteen miles directly towards the peak of Mauna Kea, flowing continuously for a period of four weeks. In the saddle between the two mountains the stream widened out and spread over the plain, being four and a half miles across in the widest part. One branch extended a considerable distance down towards Waimea on the west, evidently uniting with a former eruption known as the Keamuku flow.

The flow of 1851, beginning on August 8th, was announced by a remarkably brilliant display accompanied by detonations in the summit crater. This flow is said to have occurred from an opening on the west side of the mountain about 1,000 feet below the summit and to have extended for ten miles westerly in the direction of Kealakekua. It lasted only about four days, and is not commonly shown on maps.

In the following year, on February 17, 1852, light was again seen on the summit, and within a short time lava broke out on the northern slope of the

[12] Which would reduce the altitude, as given by him, by about seventy feet. [13] In 1907.

PLATE 42. TREE MOULDS IN PUNA.

In Puna may be seen hundreds of lava tree stumps standing erect in the fields, appearing as pillars, often fifteen feet high. Sometimes two or three stumps will be connected by the lava in various ways.

mountain, in plain view from Hilo. Fountains leaped three or four hundred feet in the air, presenting a brilliant spectacle, but within twenty-four hours the activity had apparently ceased. Three days later, February 20th, lava again broke through the side of the mountain, much lower down towards Hilo, and the stream of fire flowed for fifteen or twenty miles directly toward the town. This eruption was an especially violent one, the stream descending with astonishing rapidity. Activity lasted about five months and came to an end when its stream was about ten miles from Hilo Bay. It is a privilege, at this point, to quote from the vivid description of this eruption and flow given by the great missionary, Rev. Titus Coan, to whose labors, observations and faithful chronicles of the activities of Pele not only Hawaii but science and the world owes so much.

On the morning of February 23rd, three days after the flow started on the Hilo side, this experienced mountaineer started with a party to visit the source of the flow. On the fifth day of battling with the tropical jungle he reached the awful crater and stood at last in the light of the fire at its source.

"It was a moment of unutterable interest. I seemed to be standing in the presence and before the throne of the eternal God, and, while all other voices were hushed, His alone spoke. I was 10,000 feet above the sea, in a vast solitude untrodden by the foot of man or beast; amidst a silence unbroken by any living voice, and surrounded by scenes of terrific desolation. Here I stood—almost blinded by the unsufferable brightness; almost deafened with the startling clangor; almost petrified with the awful scene. The heat was so intense that the crater could not be approached within forty or fifty yards on the windward side, and probably not within two miles on the leeward. The eruption, as before stated, commenced on the very summit of the mountain,[14] but it would seem that the lateral pressure of the emboweled lava was so great as to force itself out at a weaker point on the side of the mountain, at the same time cracking and rending the mountain all the way down from the summit to the place of ejection.

"The mountain seemed to be siphunculated; the fountain of fusion being elevated some two or three thousand feet above the lateral crater, and being pressed down an inclined subterranean tube escaped through this valve with a force which threw its burning masses to the height of four or five hundred feet. The eruption first issued from a depression in the mountain, but a rim of scoriæ two hundred feet in elevation had already been formed around the orifice in the form of a hollow truncated cone. This cone was about a mile in circumference at its base, and the orifice at the top may have been three hundred feet in diameter. I approached as near as I could bear the heat and stood amidst the ashes, cinders, scoriæ, slag and pumice, which were scattered wide and wildly around. From the horrid throat of this cone vast and continuous jets of red-hot, and sometimes white-hot, lava were being ejected with a noise that was almost deafening and a force which threatened to rend the rocky ribs of the mountain and to shiver its adamantine pillars. At times, the sound seemed

[14] By fire showing in the summit crater.

subterranean, deep and infernal. First a rumbling, a muttering, a hissing, a deep premonitory surging; then followed an awful explosion, like the roar of a broadside in a naval battle, or the quick discharge of pack after pack of artillery on the field of carnage. Sometimes the sound resembled that of 10,000 furnaces in full blast. Again it was like the rattling of a regiment of musketry; and sometimes like the booming of distant thunder. The detonations were heard along the shore at Hilo.

"The eruption was not intermittent but continuous. Volumes of the fusion were constantly ascending and descending, like a *jet d'eau*. The force which expelled these igneous columns from the orifice shivered them into millions of fragments of unequal size, some of which would be rising, some falling, some shooting off laterally, others describing graceful curves; some moving in tangents, and some falling back in vertical lines into the mouth of the crater. Every particle shown with the brilliancy of Sirius and all kinds of geometrical figures were being formed and broken up. No tongue, no pen, no pencil can portray the beauty, the grandeur, the terrible sublimity of the scene.

"To be appreciated, it must be felt. * * * * During the night the scene surpassed all powers of description. Vast columns of lava at a white heat shot up continuously in the ever-varying forms of pillars, pyramids, cones, towers, turrets, spires, minerets, etc., while the descending showers poured in one incessant cataract of fire upon the rim of the crater down its burning throat and over the surrounding areas; each falling avalanche containing matter enough to sink the proudest ship. A large fissure opening through the rim of the crater gave vent to the molten flood which constantly poured out of the orifice and rolled down the mountain in a deep, broad river, at the rate probably of ten miles an hour. This fiery stream we could trace all the way down the mountain until it was hidden from our eyes by its windings in the forest, a distance of some thirty miles. The stream shown with a great brilliancy by night, and a horizontal drapery of light hung over its whole course. But the great furnace on the mountain was the all-absorbing object."

Three years later, in August, 1855, and continuing for sixteen months, occurred the greatest flow of the century. The point of emergence was at an elevation of 12,000 feet on the northeast side of the mountain, and the molten river took a course directly for Hilo. After fifteen or sixteen months of continuous flowing, during which the flood advanced at about a mile each week, the eruption came gradually to an end, having sent a stream of lava for a distance of many miles down the mountain side, that in places was eight miles in width at the widest part. As its lower end came within five miles of Hilo the quiet village was greatly alarmed, but fortunately no damage was done.

In 1859 activity shifted to the northwestern side of the mountain. A flow started on January 23d at an elevation of 10,500 feet, that came down to the sea on the northwest coast in two branches, at a point just north of Kiholo. On January 31st the stream had reached the sea, more than thirty-three miles in a direct line from its source—the first eruption in historic times from a high

altitude to accomplish the extraordinary feat. The river of molten stone continued to flow, advancing a great part of its length through its self-made conduit, until some time during July.

The Earthquake of 1868.

The date of 1868 is made memorable in the annals of Hawaiian history by reason of the severe earthquakes which preceded and attended the eruption of that year. The eruption which took place low down on the Kau slope—the opposite side of Mauna Loa from which previous eruptions had issued—was announced, as usual, by activity in the summit crater. On March 27th smoke was seen issuing from the top of the mountain. Within half an hour a column of illuminated cloud had risen to the height of ten or fifteen miles, but the flow did not occur at once. During the few days immediately following that portion of the island was in an almost continual state of earth shock. On April 2nd a terrific earthquake took place which shook down every stone wall and almost every house in the Kau district. The greatest shock occurred in the vicinity of Waiohinu, where the stone church and other buildings were completely demolished. The earth continued to tremble until April 7th, when lava broke out in Kahuku five thousand six hundred feet above the sea, through a great rent in the mountain side that was ten miles from the ocean. The lava spouted several hundred feet high and in two hours the torrent of fire reached the sea. Within the five days that it continued to flow, as much lava was poured out as would have issued from a rupture at a higher elevation in months. While no lives were lost in the flow three men were imprisoned several days on a hill that was completely surrounded by the lava flood, and several houses and a large number of cattle were destroyed, while more than four thousand acres of good land were turned into a worthless heap of stone.

The earthquake detached a large mass of clayey soil on the mountain side at Kapapala, causing a destructive land-slide or "mud flow" to rush down the valley for three miles in a stream, half a mile wide and thirty feet deep. Thirty human beings and five hundred or more domestic animals were overwhelmed by this earth avalanche.

Immediately following the earthquake an immense tidal wave, estimated to be forty or fifty feet in height, rolled in on the Kau coast and swept away several villages, drowning eighty people and leaving the survivors destitute. While these events were transpiring on the mighty mountain of Mauna Loa, the lava in Kilauea escaped through a great fissure which opened low down to the southwest of the crater. As the lava escaped it left in Kilauea a pit three thousand feet long and five hundred feet deep. During the same year, while the people were still in an anxious mood, on August 15th the sea about the islands made a sudden rise and fall which although attributed by some to Mauna Loa at the time, was later found to be caused by a terrible earthquake in Peru and Ecquador.

The great flow of 1880, as usual was announced by a beacon from Mokua-

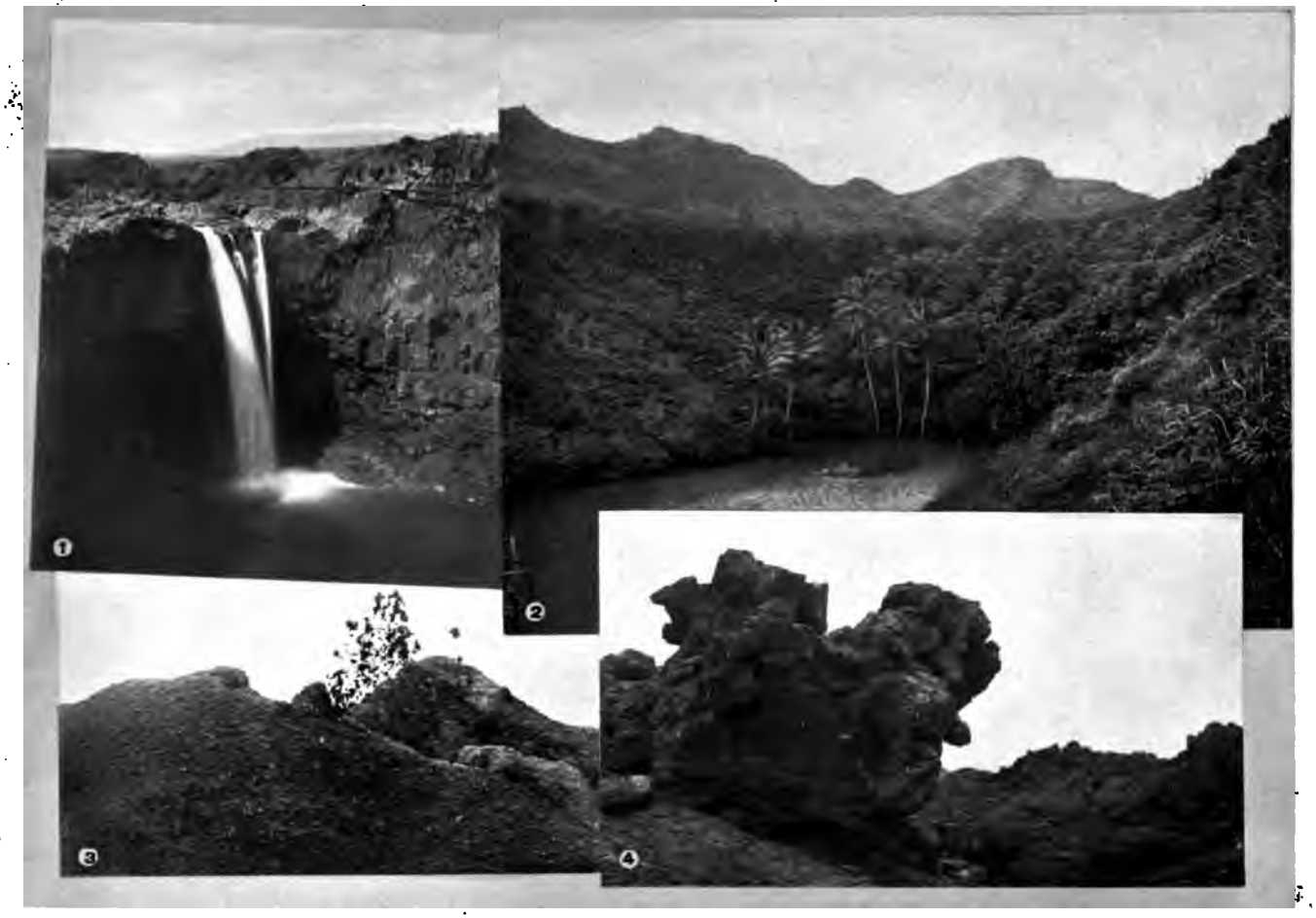

PLATE 43. VOLCANIC SCENERY ON HAWAII.

1. Rainbow falls near Hilo. 2. Green Lake in Puna. 3. Dewey Crater on Mauna Loa in eruption. 4. Huge block of aa on an old lava flow.

weoweo. The light first seen on May 1st disappeared, however, and nothing of note occurred until November 5th, when a flow started from the northeast slope of Mauna Loa at a point in the vicinity of the source of the flow of 1855. It proved to be one of the most important eruptions and flows on record in the islands. Although the amount of lava poured out did not equal that of the '55 flow, the distance covered was greater than that of any flow from any island volcano.

From an opening in the side of the mountain at an altitude of about 11,000 feet the stream soon divided into three branches. The first branch, known as the Kea stream, ran in the direction of that mountain and terminated in the flat between the two mountains. The second, the Kau stream, ran in the direction of Kilauea and was plainly seen from the Volcano House. The main stream, however, continued in the direction of Hilo, where on August 10, 1881, it finally stopped at a point only three-quarters of a mile from the town, after flowing in a tortuous course more than thirty-five miles in length. As the stream slowly but surely worked its way nearer and nearer the town, excitement was intense, not only in Hilo but throughout the group. But at last, after nine months of activity, the flow finally stopped, leaving the city unharmed.

In December of the year 1886, earthquakes became frequent and violent on the opposite side of the mountain; about Kahuku they increased in frequency until from three to six hundred were noted by different observers in the two or three days between January 17th and January 19th, 1887. Light was seen at the summit several times during this period, but it was on the afternoon of the 18th that the outbreak occurred at 6,500 feet elevation and at a point twenty miles from the sea on the Kahuku side of Mauna Loa.

The following day by noon the lava stream had reached the sea at a point four miles west of the flow of 1868. By noon of the 24th the flow ceased, but not until more lava had been poured forth than during the earlier flow.

Activity was renewed in 1899 on the north slope of Mauna Loa at what was called the Dewey Crater, out of compliment to the distinguished admiral whose achievement at Manila Bay was coincident with that of the eruption. On June 20th earth shocks were felt in Hawaii, and on July 1st light was to be seen over the pit in the top of the mountain. On July 5th there came an outbreak of lava on the slopes six miles northeast of Mokuaweoweo. The point of eruption was at an elevation of near 11,000 feet, a short distance above the point of origin of the 1880 flow. Fountains of fire could be seen spouting high in air, and parties started at once from Hilo and the Volcano House to visit the source of the flow. It was found that two fountains were in operation almost a mile apart, but later the upper one died down and a third became active near the second. The streams from these fountains united and flowed towards Mauna Kea. The lava continued to flow until July 26th, running fifteen miles from its source in a stream which was a mile in width at the widest part.

Eight years passed before Mauna Loa again gave forth an eruptive flow.

PLATE 44. VARIOUS HAWAIIAN VIEWS.

1. Lava tree casts in Puna. 2. General view of the flow from the 1905 eruption of Mauna Loa. 3. Party on the way to the end of the flow. 4. A field of aa or rough lava. 5. Climbing over a new lava flow. 6. The Akaka falls, Honomu, Hawaii. 7. A field of ropy lava, 1907 flow.

As usual, the first intimation of activity was given by the lurid glare over the summit crater. On January 9th slight earthquakes were felt on Hawaii, and on the night of January 10th, 1907, Mauna Loa was crowned with a bright light. A few hours later the molten flood broke through the walls of the great mountain on the southerly or Kahuku side of the dome, at a place 8,500 feet above the sea and at a point about one half the distance from the sea to the summit of the mountain. The flow in its course down the mountain passed near the path of the 1887 flow. About the middle of its course the stream divided into two main divisions, with smaller branches to right and left. The two main branches crossed the government road five miles apart on the night of January 13th, i. e., within three days from the time of the outbreak. Neither of the streams in their divided and weakened condition had force enough to reach the sea. Both came finally to a halt on January 24th, about four miles from the shore and within ten days from the time the flow broke out on the mountain side. It has been estimated that in the upper part of the stream the lava flood advanced at the rate of seven miles an hour, but lower down its advance was slow and majestic. Several hundred people from the vicinity and from the other islands of the group rushed to the scene and were favored with a splendid view of nature's most awe-inspiring spectacle.

On November 25, 1914, white fumes were seen rising above the crater on the summit of Mauna Loa. By evening the fume columns were seen to rise to a height of 6,000 feet or more above the mountain, and, illuminated by the light from below, presented a spectacle of splendid magnitude and beauty. It was generally thought that this manifestation was the percursor of the usual type of outbreak and flow, but this event did not transpire. After a short period of varying activity, confined entirely to the crater of Mokuaweoweo, the outbreak subsided until no activity was visible from the observatory at Kilauea.

Lava Discharged in the 1907 Flow.

Mr. E. D. Baldwin has estimated that the flow of 1907 covered nine hundred acres of rough land and that a volume of two hundred million cubic yards of basaltic material was poured out. The flow of 1855 covered 15,000 acres and represented a discharge of six hundred million cubic yards of basalt. The flow of 1880-81 covered 20,000 acres and equalled at least five hundred and forty million cubic yards of lava. These estimates are necessarily suggestive rather than accurate. When we look at the mountain as a whole we see numerous streams of similar proportions showing plainly on its surface. Looking deeper we find it made up of countless thousands of similar streams and conclude that at the present rate of growth millions of years have elapsed since the building of the mountain first began.

Work of Hawaii's Volcanoes.

It should be observed that during the period of more than one hundred years that Mauna Loa and the volcanoes of Hawaii have been under observation

not a single person has perished in the molten floods that time and time again have been poured out, though tens of thousands of acres of the island's mountain slopes have been made desolate and blackened, so that fertile land and peaceful valleys have been choked and left worthless when the torrent of liquified stone had ceased to flow.[15]

One's veneration for this great mountain increases when it is understood that it is in this way and by the same process that the whole group of islands has been built up. A large view of the amplitude of geologic time can be gained by reference to a map showing the comparatively small proportion of the four thousand square miles of the surface of Hawaii that after all has been scourged by fire within one hundred years. But when it is known that all the material which composes this island, like that of the other islands of the group, must have been forced up from beneath the floor of the ocean to be poured out on the sides of the mountains, one can better understand how great the combined flows must have been. However, in arriving at an understanding of the amount of volcanic work that has been done in the group it is important to take into account the broad bases of the islands as well as that portion which towers above the ocean's surface.

Geologists are fond of regarding Mauna Loa as an excellent example of a volcanic mountain that has gone on slowly adding to its bulk until it has attained to near the limit in altitude to which the subterranean forces can lift a column of liquid lava.

The story of the titanic phenomenon attending the rise and fall of the lava in the chimney which ends with the summit crater on Mauna Loa would furnish material for an interesting chapter, but it seems wise to devote the limited space available to a brief account of the active volcano Kilauea, on the remaining mountain of the island.

CHAPTER XIII.

KILAUEA, THE WORLD'S GREATEST ACTIVE VOLCANO.

Reference to a map will show Kilauea located apparently on the slope of Mauna Loa and well to the southeastern part of the island of Hawaii. The name is directly applied to the world's largest active crater, which in reality is the center of activity of a shattered mountain 4,040 feet high. As the crater is easily reached by automobile and train from Hilo Bay, on the north, and as the journey can be extended past the crater to Honuapo on the sea-shore on the opposite or southern side of the mountain, where the steamer can be taken for the return trip to Honolulu by way of the Kona coast, there is, perhaps, no better way for completing our account of the geology and topography of Hawaii, and at the same time presenting the grandeur of the crater and the pleasure of the journey to it, than by following the route ordinarily taken by tourist travel-

[15] The mud flow of 1868, however, claimed a large number of human victims.

ers. But before such a journey is undertaken it is well to be informed of some of the more important facts connected with Kilauea's long, varied and interesting history, a history that in a way prepares the visitor to appreciate what is to be seen at the great caldera as one stands on the very brink of the burning lake where the island-building activity is actually going on.

Kilauea an Independent Crater.

Geologists supposed for a great many years that Mauna Loa and Kilauea were very closely related or sympathetic volcanoes. Further study, however, has demonstrated that they are distinct in all essential features and may act in the main entirely independent of each other, though there may be some remote connection, as the eruptions in 1832, '49, '55, '68, '77, '87 and 1907 occurred in both craters during the same years. The belief in reference to their intimate relation seems to have grown from hasty conclusions based on the superficial fact of their proximity, their relative size and the further fact that they both were more or less continually active. To the casual observer Kilauea, situated as it is on the southeastern slope of Mauna Loa, appears to be but a secondary crater,—a mere wart—on the side of the great dome that rises almost ten thousand feet above it.

Whether Kilauea was formed before or after, or at the same time with Mauna Loa, its action in recorded time has generally been of a character to prove it more or less independent of the summit crater. While eruptions have taken place on top, Kilauea, much lower down and only sixteen miles distant, has often exhibited no signs of active sympathy. So through a long period of activity it has proved itself to be a distinct crater, doing the work it has to do in its own way and for that reason it is quite properly admitted to be the world's greatest active crater.

Dimensions of Kilauea.

To give some idea of the magnitude of Kilauea it is necessary to give a few of its main dimensions. The Volcano House, which is a comfortable hotel located on the very edge of the crater, is 4,040 feet above the sea. The crater from north to south measures 2.93 miles[1] and from east to west 1.95 miles.[2] Its circumference is 7.85 miles[3] and the floor of the crater has an area of 4.14 square miles.[4] From the Volcano House at the present time it is 484 feet down to the floor of the crater, which is made up of an uneven mass of cold, ink-black, shining lava. To reach the present scene of action the visitor must descend into the crater and cross over this floor for two miles to the brink of the pit Halemaumau, in the bottom of which perhaps one hundred and fifty feet below the observer, the red hot lava will be seen boiling in a wild, mad fury.

If what has been said is sufficient to fix in mind a great, roughly oval-shaped crater with approximately vertical walls, and to make it clear that the bottom of this caldera is now formed of black lava of recent origin, and that it is five

[1] 15,500 feet. [2] 10,300 feet. [3] 41,500 feet. [4] 2650 acres.

PLATE 45. VIEWS OF KILAUEA.

1. The Volcano House. 2. View from near the hotel overlooking the floor of Kilauea with the pit of Halemaumau in the distance. 3. Looking into the pit of Halemaumau from which gas and vapor rises in a dense cloud during periods of slight activity. 4. On the floor of the crater showing the various flow forms taken by the lava as it cools.

hundred feet below the highest point[5] on the rim of the crater, and that in historic time the black lava floor has never been higher than it is at the present time—there should be little difficulty in following a condensed history of Kilauea.

For our purpose its history can best be related by selecting extracts from a few of the best descriptions of conditions at the crater taken from the many accounts written by eye witnesses.

An Exploded Mountain.

This is done with a view to bringing out two points: the first that just as Mauna Loa is an excellent example of its type, Kilauea is an example of a different and rarer type, namely, a broken down or exploded volcano, that continues active. It is for this reason that it is spoken of as "safe" and, so far as volcanoes can be, is regarded as perfectly tame, "docile," and well-behaved. The second point to be developed is that of the character and periodicity of its normal eruptions.

The explosion or explosions which undoubtedly broke Kilauea down and prevented it from building up as Mauna Loa has built up, has left an unmistakable geologic record.

Evidence of what transpired is to be found on every hand. These explosions, of which there apparently were several, must have been in the very distant past. Their effect was to weaken and shatter the walls that surrounded the crater, leaving the mountain scarred by a series of radial and concentric cracks that could have been produced only by an explosion deep down within the crater. As a consequence, when the molten lava rises to a certain level in the crater, the pressure becomes so great on the lateral walls of the volcanic pipe that the lava flood breaks through some weak spot, usually far down underneath, and the liquid lava often flows quietly out to sea through some old deep-hidden conduit.

The Rise and Fall of the Liquid Lava.

Never since the coming of white man to Hawaii has there been sufficient force to lift the liquid lava over the brink of the crater. As a result of these subterranean ventings Kilauea is esteemed as the best example of a "welling" crater to be found.

The history of this volcano has been that through a period of months or years[6] the pit of Halemaumau[7] fills up little by little until it reaches the maximum of height and pressure that the walls will bear. Then, owing to the enormous lateral pressure exerted by the molten column of lava, the weakened walls give way and the crater vents itself. The lava lake recedes to a lower level, often disappearing entirely, only to fill up again in due process of time. Thus in the welling and venting of Kilauea we have a sort of barometer that indicates the conditions prevailing far down beneath the island.

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[5] Uwekahuna. [6] Perhaps owing to some unknown influence of the goddess Pele—who knows?
[7] The house of everlasting fire.

This welling of the liquid lava is in marked contrast to what takes place at volcanoes of the explosive sort. Their vents seal over after each explosive eruption, and to all appearances they die out apparently to remain dead forever Usually, however, they awake and explode without warning, presenting a magnificent spectacle of volcanic power that results too often in all the horrors attending the loss of life and property.

At Kilauea, as has been stated, different conditions prevail. The action there is confined, in the main, within the crater itself, and the interest centers in what actually takes place in the lower pit of Halemaumau rather than, as on near-by Mauna Loa, in the flow which may course down the mountain side.

The Explosive Eruption of 1789.

Without doubt one of the most remarkable exhibitions of volcanic force which has occurred at Kilauea since the islands were first inhabited by the natives occurred in the year 1789—a little over ten years after the discovery [8] of the group by Captain James Cook.

In November of that year, Keoua, a native chief of Hawaii, with a band of followers set out from Hilo to return to Kau in pursuit of a rival chief whose warriors in his absence were invading his home district. Hastily returning from Hilo with reinforcements, the shortest route took him by the overland trail which passed the brink of the volcano Kilauea. They camped at the crater two days, during which time it was very active. On the second night, being in a state of terror and scarcely knowing which way to proceed, they divided into three companies, presumably for safety, and set out upon their journey in fear and trembling. The party in the lead had not proceeded far, according to the historian Dibble, "before the ground began to shake and rock beneath their feet and it became quite impossible to stand. Soon a dense cloud of darkness was seen to rise out of the crater, and almost at the same instant the electric effect upon the air was so great that the thunder began to roar in the heavens and the lightning to flash. It continued to ascend and spread abroad until the whole region was enveloped and the light of day entirely excluded. The darkness was the more terrific being made visible by an awful glare from the streams of red and blue light, variously combined, that issued from the crater below, and lit up at intervals by the intense flashes of lightning from above. Soon followed an immense volume of sand and cinders which were thrown in high heaven and came down in a destructive shower for miles around. Some few persons in the forward company were burned to death by the sand and cinders and others were seriously injured. All experienced a suffocating sensation upon the lungs and hastened on with all speed.

"The rear body which was nearest the volcano at the time of the eruption seemed to suffer the least injury, and after the earthquake and shower of sand had passed over, hastened forward to escape the dangers which threatened them,

[8] December 8, 1777.

and rejoicing in mutual congratulation that they had been preserved in the midst of such imminent peril. But what was their surprise and consternation, when coming up with their comrades of the center party, they discovered them all to have become corpses. Some were lying down, and others sitting upright, clasping with dying grasp their wives and children and joining noses[9] as in the act of taking final leave. So much like life they looked that they at first supposed them merely at rest, and it was not until they had come up to them and handled them that they could detect their mistake. Of the whole party, including the women and children, not one of them survived to relate the catastrophe that had befallen their comrades."

This eruption, which occurred more than one hundred and twenty-five years ago, far surpassed any subsequent one, and being explosive in character was of a totally different nature from any that has since occurred. It does not seem too much to conclude, therefore, that it was possibly at that time that the final breaking down and shattering of the mountain occurred, though explosive eruptions that preceded it in the more remote past must have been much more severe.

At any rate, during the fifteen or more times that Kilauea has welled up since 1789, there has been nothing even remotely suggestive of an explosive eruption, and it is the general belief that so long as the crater remains open as it now is there is little or no danger to be expected from it.

Space will only admit detailed reference being made to three of the many stages through which this crater passes in completing an eruptive cycle. The material here presented is selected from the wealth of descriptive matter now available from the records of its varying moods left covering almost one hundred years, and from which I have condensed a brief history which is appended in the following chapter for convenient reference.

Conditions at the Crater in 1823.

In 1823 the crater was visited and described for the first time by a white man. The distinguished missionary, the Rev. William Ellis, witnessed at that time a wonderful display. From his description we conclude that the crater appeared far different from what it does now. It was evidently venting itself at the time of his visit and the lava was flowing out from deep down under the lake of fire. The drawing off of the lake of lava left a comparatively narrow black ledge about the inner wall of the crater on all sides as the lava sank lower and lower. This observer found a place at the north end of the crater down which he descended to the black ledge. His first impressions of the crater, however, were those gained from the highest point[10] on the west side of the crater, eight or nine hundred feet above the lava lake, and were as follows:

"Immediately before us yawned an immense gulf, in the form of a crescent, upward of two miles in length, about a mile across, and apparently eight hun-

[9] Their form of expressing affection. [10] Uwekahuna.

PLATE 46. IN AND AROUND KILAUEA.

(For Description of Plate See Opposite Page.)

dred feet deep. The bottom was filled with lava and the southwest and northern parts of it were one vast flood of liquid fire in a state of terrific ebullition, rolling to and fro its fiery surge of flaming billows. Fifty-one craters of varied form and size rose like so many conical islands from the surface of the burning lake. Twenty-two constantly emitted columns of gray smoke, or pyramids of brilliant flame, and many of them at the same time vomited from their ignited mouths streams of fluid lava which rolled in flaming torrents down their black indented sides into the boiling mass below." That evening, "between nine and ten, the dark clouds and heavy fog that since the setting of the sun had hung over the volcano gradually cleared away. The agitated mass of liquid lava, like a flood of molten metal, raged with tumultuous whirl. The lively flame that danced over its undulating surface tinged with sulphurous blue or glowing with mineral red, cast a broad glare of dazzling light on the indented sides of the insulated craters whose bellowing mouths, amidst rising flames shot up at frequent intervals with loudest detonations, spherical masses of fusing lava or bright ignited stones." The following year Ellis revisited the crater and remarked on its much abated activity.

Kapiolani Breaks the Spell of Pele.

Brief as this sketch must be, I am impelled to interpolate an event that occurred in the history of the islands about a year after the events described by Ellis. Kapiolani,[11] daughter of a great chief of Hilo, was one of the noblest characters of her time. Though intemperate and dissolute in early life, she soon became an example of virtue and refinement to her countrywomen and excelled them all in the readiness with which she adopted civilized habits and Christian customs. In December, 1824, four years after the arrival of the missionaries in Hawaii, she determined to break the spell of Pele—the dread goddess of the volcano—to whose mythical power frequent allusions have been made.

In spite of the opposition of her friends and husband she made a journey of one hundred and fifty miles, mostly on foot, in order to defy the wrath of Pele in her abode in the crater, and thereby prove to her people that no such being existed.

It is related that as she neared the volcano she was met by an old priestess of Pele who warned her not to go near the brink of the crater, and predicted her death if she violated the tabus of the great goddess.

Undaunted by the warning of the priestess, Kapiolani went forward and

[11] The captive of Heaven.

Description of Plate.

1. The sulphur banks near the Volcano House; note the effect of the sulphur fumes on the trees and plants. 2. Kilauea-iki with the floor of smooth shining black lava. In the foreground may be seen the flow that ran into the pit in 1832. 3. Flashlight view in Pele's reception room. The light streams in through an opening in the roof in the farther end of the cave. 4. Waldron's Ledge near the Volcano House showing the depth of the crater of Kilauea.

spent the night on the brink of the crater in a rude grass hut constructed for her shelter. In the morning she and her little company of followers descended into the crater to the black ledge just mentioned, and there in full view of the grand and terrific action of the inner crater at her feet, she ate the sacred ohelo berries consecrated to Pele, and hurled stones into the burning lake, saying "Jehovah is my God. He kindled these fires, I fear not Pele. If I perish by her anger then you may fear Pele, but if I trust in Jehovah and He preserves me when breaking her tabus, then you must fear and serve Him alone."

As the courageous woman was unharmed the belief in the mighty spell of Pele was broken, and thus was accomplished what has very justly been called, "one of the greatest acts of moral courage ever performed."

The Eruption and Flow of 1840.

Returning to our account of the crater, we must pass over the remarkable eruption of 1832, when in two years the lava welled and dropped a thousand feet, and consider for a moment the great eruption and flow of 1840, which illustrated so splendidly an important phase of activity at the volcano.

For eight years after the eruption of 1832 the process of refilling the caldera of Kilauea had been going on until at last the black ledge surrounding its inner walls, as seen and described by Ellis, had been covered with new lava about one hundred feet deep. Kilauea after eight or nine years of cumulative work was ready for an outbreak, and in the summer of 1840 an extensive eruption took place. The event was minutely recorded by the Rev. Titus Coan.

After a period of intense ebullition in the pit the customary break-down occurred, but on this occasion, in place of venting deep down in the bowels of the earth, the lava worked its way to the eastward in the direction of Puna through some old subterranean conduit, perhaps a thousand feet beneath the surface of the mountain, until it emerged in the bottom of an ancient wooded crater, eight miles distant from Kilauea. Its course all the way to this place could be distinctly traced by the rending of the earth's crust into innumerable fissures and by the emission of steam and gasses.

From the old crater, which was four hundred feet deep, the lava stream continued on its way seaward; part of the time deep down under the earth; part of the time flowing over the surface as a river of fire. At last, flowing in this way for several miles, it again broke out like an overwhelming flood, and sweeping forest, hamlet, plantation, and everything before it, rolled down with resistless energy into the sea. There, leaping a precipice of forty or more feet in height, it poured itself in one vast cataract into the depths below with loud detonations, fearful hissing, and a thousand unearthly and indescribable sounds. Imagine this mighty Niagara of fire pouring its livid flood into the ocean night and day for three weeks. The atmosphere in all directions was filled with ashes, spray and gasses; the coast was extended into the sea a quarter of a mile, a sand beach and a new cape were formed, while the light was so great that print could be read at midnight forty miles at sea.

The whole course of this stream from its source at Kilauea to the sea was about forty miles. During the flow the lava in the crater fell about 300 feet and Pele's fires became nearly extinct. The story of the eruption as given by Rev. Titus Coan is one of the most thrilling accounts of volcanic activity ever written.

Eruption of 1892-94.

So many and so varied are the scenes that have been witnessed at the crater that it is necessary to select only such as may form types of its activity. For that reason we pass to the eruption of 1892-94, since it represents the height of activity within the crater during the last score of years, and it is especially interesting as the conditions then were the culmination of a period of activity similar to that now (1913) in progress at the crater.

Through a period of several months the lava in the pit of Halemaumau continued to rise slowly until a new lake, differing from those that had preceded it, was formed at a higher level than had before been known—260 feet below the Volcano House. This lake was held in a superficial bowl, made of loose fragments of solidified lava that were more or less firmly cemented together by splashings from the lake within, or by occasional overflows which ran down its side and out onto the floor of the crater. In due time the old law of pressure went into effect and within a few hours the liquid lava lake had vanished, leaving the pit an empty smoking chimney, 750 feet deep.

Activity in 1902.

In August, 1902, the fires in the bottom of the pit were again rekindled after a long period of comparative quiescence. The period of increased activity at this time, as usual, was heralded by an increase in the volume of smoke-like vapor which issued from the pit of Halemaumau. Night and day for months this great titanic chimney rolled its cloud of heavy vapor skyward. At length the never-failing sign of a change came: the vapor decreased in volume and became thinner and bluer. Soon after an eye spot of fire became visible at the very bottom of Halemaumau, 750 feet below the present rim of the pit; slowly, day by day, the lava lake rose and increased in size, being fed by a burning spring from below. In October of that year I visited the crater and at that time made a careful survey and sketch model of the whole region, from which data I afterwards constructed the large model that forms the central feature of the exhibits in the "Hawaiian Hall" in the Bishop Museum. The lava on that occasion was more than 500 feet down in the pit. Soon afterwards the bottom quietly dropped out and the lake of fire entirely disappeared, and the smoke-like vapor began silently and steadily to gush forth. Madam Pele of her own accord had retired once more deep down into the secret inner chambers of her ancient abode.

The Activity in 1907.

With the exception of the slight activity of 1903 but little has transpired in the pit until the present eruption which began early in the year 1907, and has

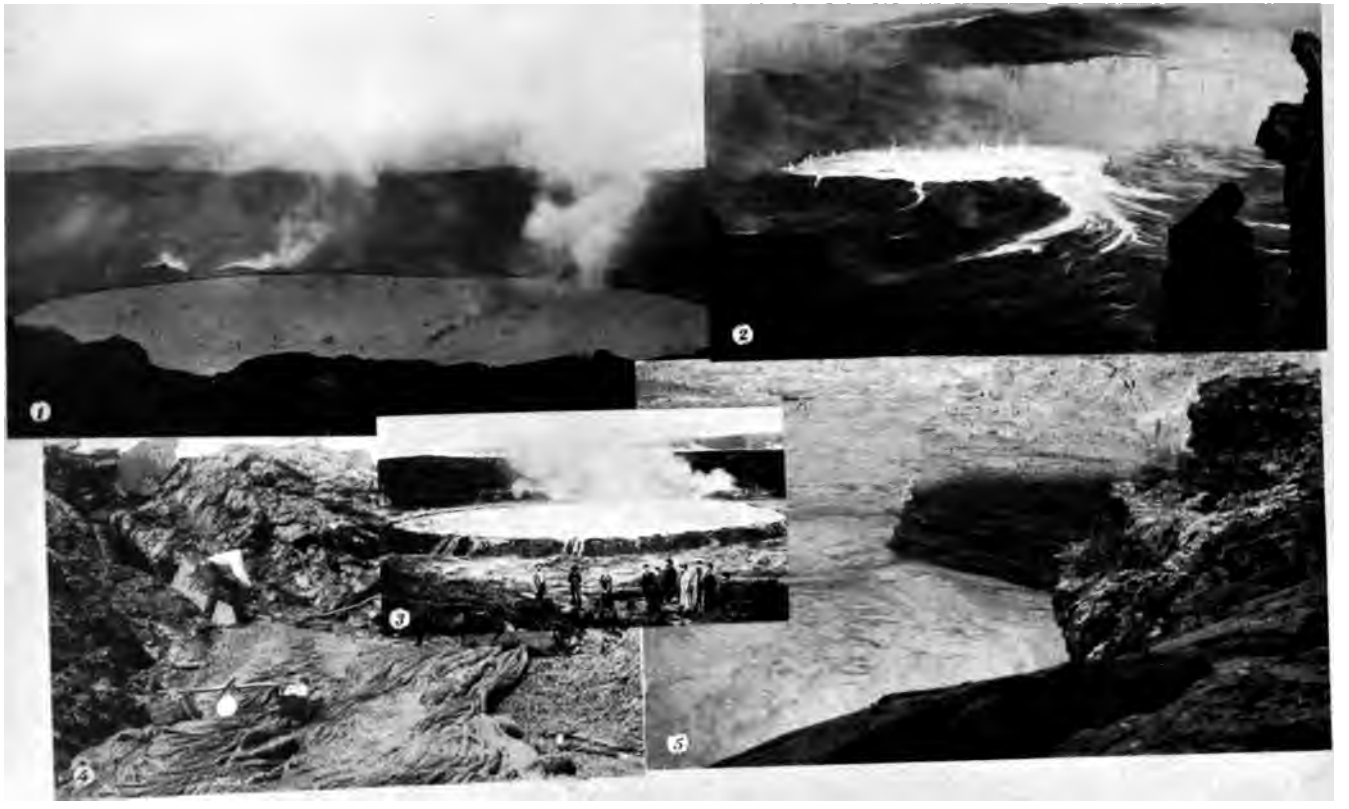

PLATE 47. VIEWS OF THE PIT OF HALEMAUMAU.

1. Showing the flood conditions in the pit, 1909. (From a painting by D. Howard Hitchcock.) 2. A cone building up on the lava lake within the pit. 3. The pit of Halemaumau overflowing in 1894. 4. A recent flow of Halemaumau, on the floor of Kilauea. 5. Near view, looking down into the pit of Halemaumau.

continued to the present with much variability in the character of the lava and with many spectacular displays that have been enjoyed by an increasing company of travelers. The lava in Halemaumau on September 4th, 1908, was but ninety-five feet below the rim of the pit. By the following summer the lake was 235 feet below the rim, but by the end of the year it was well up towards the black mark left high on the walls of the pit in the preceding year.

A Visit to Kilauea in 1909.

It was in this favorable condition for observation when I visited the crater in December, 1909, and climbed down into the pit to the very edge of the burning lake. As that journey, out of the several that I have made to the volcanic region was an especially pleasant one, I venture to relate briefly the main incidents of the outing since, to the tourist, as well as those who are so fortunate as to live in Hawaii, the visit to Kilauea is one of the most interesting experiences of a lifetime.

The trip from Honolulu to Kilauea is always pleasant and well worth making, no matter whether the crater is active or not. The journey by boat, although rough while crossing the channels between the islands is filled with varied and delightful experiences for the traveler. The scenery from the steamer's deck is everywhere and at all times most fascinating. The landing at Lahaina, Maui, the quaint old capital of the group, the sunrise over the mountains at Kawaihae Bay, and last and best of all the grand panorama along the Hamakua coast, the glory of which has already been referred to, form never-to-be-forgotten incidents.

The seventy miles that the steamer skirts the northeast or Hamakua side of Hawaii affords a splendid opportunity to study the topography of the island as a whole, but particularly in that section, and to note the great transformation which the development of the island's sugar industry has brought about all along the uplands in the foreground. Along the coast dozens of waterfalls, varying in size from a mere silvery strand of water to mountain torrents, pour over the abrupt sea cliffs and dash into the ocean below. Many of these falls plunge down hundreds of feet in a single leap. As the vessel proceeds one has little difficulty in counting as many as a dozen or fifteen good-sized falls in sight at one time. All too soon the voyage is over and the landing at Hilo is made.

Hilo.

The people of Hilo claim their town to be the most beautiful one in the group. Almost daily showers cool the air and refresh the vegetation, and the sea and mountain breezes remove the dampness that otherwise would produce a moist, heavy climate. The soil of the valley is rich and deep, and being well watered it is highly productive.

The location of the town is most charming with its fine bay, its improved harbor, and picturesque Cocoanut island in the foreground. On the other hand its background is formed by a superb view of Mauna Loa and Mauna Kea in

the distance. Every turn in the street invites one to linger or to turn aside and explore. The subdued sound of a nearby waterfall, the gurgle of the shining river, the calling of the birds, the trees, the flowers, the twining vines, all cast a spell of peace and contentment over the place and make one feel he could stay, yes, live, and be happy forever in this enchanted little city by the sea.

The natural points of special interest near Hilo for a tourist and a naturalist are Cocoanut Island, Rainbow Falls, Onomea Gulch and Arch, the Akaka Falls,[12] at Honomu, and the Kaumana caves in the flow of 1881,—caves that are in reality great tunnels left by the escape of the lava from the conduits that brought it down from the mountain in the distance. From Hilo it is possible to visit the Puna district and the flow of 1840 as a side trip. The railroad to Kapoho passes over this interesting surface outbreak described above and furnishes an opportunity for its inspection. The district is also famous for the lava tree casts caused by the lava flowing through the forests at Kapoho; the Green lake in a small extinct crater and the famous heiau, Wahaula.[13] A warm spring with a small pool in which the water is constantly at a temperature of blood heat, and a number of small craters are all objects of interest.

The Ascent of Kilauea.

The journey from Hilo to the volcano may be made by the railway or by the wagon road. By train one may go to Glenwood, twenty-two miles on the journey. As the train rumbles along over a good road bed, through immense plantations of sugar-cane, and splendid forests of hard-wood timber, by flourishing mills and quiet retreats, one wonders if, after all, there has not been some mistake, for nowhere can one see signs of the devastation by quaking earth and blazing flood that are so intimately associated with the popular idea of a great active volcano.

The whole journey from Hilo to the crater can be made by automobile. If the railway route be taken after the transfer at Glenwood, for an hour the auto winds up over a gradually ascending macadam road, through a delightful tropical forest. The splendid woods with wonderful clinging vines produce a jungle of flowers and trees and shrubs and ferns. Great feathery fern trees lean out over the road so that the auto is driven beneath them. Occasionally these giant ferns grow into a veritable forest with many trees thirty or forty feet in height. Along the roadside bright flowers spring up that are often familiar flowers run wild. Here a clump of Cannas or a bunch of fragrant ginger; there a tangle of beautiful roses that have escaped from some abandoned garden; farther on are great masses of nasturtium and wild morning-glories. Objects of especial interest are the wild berries and the bananas by the wayside. Thimble berries abound and are recognized as great glorified raspberries—an inch or more in diameter. The ohelo, an upland cranberry, grows in patches

[12] 500 feet.
[13] A model of this heiau that the writer assisted in assembling, may be seen in the Bishop Museum.

by the roadside. It was berries like these that were long ago made an offering to Pele. Their presence reminds one that we must be nearing her domain.

Bundled up in winter wraps as a protection against the cool of the higher elevation one finds it hard to realize that back yonder by the sea-shore, scarcely 4,000 feet below, groves of cocoanut trees are nodding in the languid warmth of the tropical summer afternoon. But before long the auto rounds a curve in the road and the Crater Hotel, a well-appointed though comparatively new hostelry, is in sight. About a mile further is the old-established Volcano House, the very personification of hospitality and good cheer. To the left and just beyond the Volcano House, and until this moment hidden from view, looms up the great caldera. Even then one can hardly realize that the journey to the world's great inferno is really at an end.

First View of the Crater.

Those who are as enthusiastic as they should be join a horseback or an automobile party that very afternoon and ride down into the crater to get a view of the eternal fires, for fear, as sometimes happens, they may have vanished before the morrow. If worn from the journey and suffering from the effects of a choppy sea while crossing the channels, the traveler may sit in the great observation room on the hotel lanai and rest and drink in the reflected grandeur of the fires that, as darkness gathers, paint their fury on the fleecy white clouds that silently drift over nature's great melting-pot, the dark outlines of which can be traced by its own light reflected back from the sky.

In the morning the great crater looms out of the fog—black, silent and sublime. The view in the early morning is most fascinating, but, as one's time is always limited and as there are other sights to be seen near at hand, it is customary to pay a visit to the sulphur beds before breakfast.

Steam Cracks and the Sulphur Bed.

It is a weird sight to see the steam rising from the cracks and crevices on every side and to know that for years, centuries perhaps, these same exhausts of steam have played without increased or diminished volume. It is not uncommon to find a hotel servant busily engaged heating water over one of the nearby steam cracks, preparing to wash the hotel linen. A few rods farther on past the hotel the sulphur beds themselves are to be seen steaming and sparkling in the morning sun. They cover several acres in extent and are a never-ending source of delight and wonder. There perhaps for the first time one breathes real sulphur fumes and realizes not only that the earth under foot is hot, too hot to stand on in places, but that it is slowly being added to, bit by bit, as nature quietly deposits there minerals in forms so delicate in structure, and beautiful in color, that they crumble and dissolve as the wonderful yellow and pink and white masses of newly-formed crystals are held in hand. While the amount of sulphur deposited is not great it is in some cases quite pure. As the sulphur is usually mixed with the red clay formed by the decomposition of

the lava owing to the chemically charged steam, it is of value only as a curiosity, and specimens of sulphur, sulphate of soda, lime and alumina are usually carried away.

KILAUEA-IKI.

A short expedition is usually made on foot to Kilauea-iki[14] before descending into the main caldera. The small lateral crater, while connected with the larger one is, in many ways, really a side issue. It is less than half a mile to the east of the north end of the main crater and a little over a mile from the hotel.

It has not been active for more than half a century but in spite of that it is full of interest to the geologist, as it is a splendid example of a pit crater. It is 740 feet deep[15] an dis more than half a mile[16] across the top. In 1832 a severe earthquake shattered the wall which separated this crater from Kilauea and large crevices opened in the sunken neck of land which unites the two craters. From the earth rents along the south side of the isthmus a curious flow of brown lava ran to right and left, entering both the craters, but the amount of lava emitted was very slight. Nevertheless, the lava as it entered Kilauea over the bank formed a fall 200 feet in height that is plainly seen from the Volcano House. The black shining lava floor in Kilauea-iki was a result of the activity in the main crater in 1868; since then the smaller crater has been quiet and apparently dead.

KEANAKAKOI.

To the south of Kilauea-iki and on the flat plain surrounding Kilauea at a point almost due east of the pit of Halemaumau is a still smaller lateral crater with vertical walls known as Keanakakoi.[17] The present floor of this pit, the result of activity in 1877, is below the floor of Kilauea. It is of interest to note that this crater derives its name from the fact that old-time Hawaiians found there suitable material for the manufacture of their stone implements, but the eruption just mentioned obliterated all trace of their workshop.

Both of these lateral craters are now skirted by the new automobile road known as Echo Trail, a name due to the fact that five distinct echoes can be heard from the west bank of Keanakakoi. The road leads down into Kilauea at this point and crosses its floor to the pit, enabling one to run a motor car to the very brink of Halemaumau with ease and safety.

THE DESCENT INTO THE MAIN CRATER.

As the descent into the main crater is the chief concern of the visitor and is usually made on foot or on horseback, it is customary to make the start early in the afternon, prepared to have a lunch beside the pit, in defiance of Pele, just as Kapiolani did almost a century ago. However, no one should miss

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[14] Little Kilauea. [15] 867 feet below the Volcano House. [16] 3300x2800 feet.
[17] The workshop of the adzemaker.

the view of the eternal fires by night, since the night view is even more wonderful than the display by day.

With horses, staffs, guides, lanterns and lunches in readiness the start is made. To reach the floor of the crater by the usual route the visitor must descend several hundred feet by a bridle path that angles back and forth down the face of old fault blocks that lie like steps one lower than the other, at the north end of the crater at a point just below the Volcano House. The descending path leads down through a scrubby wood where native birds are to be seen fluttering about, singing their carols with little regard or concern for the spectacle so near at hand.

Arriving at the floor of the crater 484 feet below the Volcano House, one turns to look back at the imposing wall known as Waldron ledge,[18] with its vertical face marking the extreme depth of the crater. Stretching away in the opposite direction is the rough, irregular, glistening black floor of the crater.

Heat Cracks and Spatter Cones.

One of the first points of interest, after passing observation hill, is the great crack that opened on the crater floor, fifteen or twenty feet wide and half a mile long. It opened without warning a number of years ago (November 4th, 1889) while a party of visitors were down at the pit. On their way back to the Volcano House they found this yawning gulf where they had passed without fear but a few hours before.

The journey across the lava field is full of interest, especially to one on foot. There are great hollow domes of lava one or two hundred feet long by twenty or more feet in height to be climbed; cracks and fissures to be inspected and many curious forms and freaks that the lava takes in cooling to be studied or puzzled over. Then there are the steam crevices, and heat crevices, and gas crevices to be examined and tested. An innumerable number of caves of different sizes have been formed by the change brought about by the cooling lava. Among the more important perhaps are Pele's reception room, as cool and inviting as her kitchen is hot and oppressive. Here hundreds of visitors have left their cards scrawled over with messages to the great goddess. Then there are the curious stalactite caves where the walls and floors are covered with tube-like stalactites and stalagmites formed from the mineral-charged water which percolates through the porous lava.

The corral where equestrians dismount and tie their horses is a rough enclosure beside the trail a quarter of a mile from the fiery lake. From it the elevation to the edge of the pit is quite noticeable. Along the path the sulphur cracks become more numerous. A little way to the right the heat issues from the cracks over an area several acres in extent, that, owing to the deposits of soda and sulphur, appears white against the dark lava that surrounds it. It is here that tourists amuse themselves by scorching souvenir postal cards by tuck-

[18] Named for the purser of the U. S. Exploring Exepdition (1840).

ing them into the crevices; or by boiling coffee and frying bacon and eggs over the escaping heat.

It is quite common to find scattered over the surface or collected in crevices of the rock curious greenish and yellowish threads of spun-glass called Pele's hair. When the fire lake is in violent ebullition small masses of lava are thrown into the air as the fountains play. The threads, which are drawn out after the fiery drops harden, are carried high by the uprising current of air from the pit and are dropped later over the floor of the crater.

Close to the corral is a low spatter cone, the "little beggar," which appeared in 1884 when the lava was occasionally overflowing the top of the dome which now surrounds the pit. Near at hand is "the devil's picture frame," a hole in a small lava fall that ran down into a shallow cave in the crater floor. Beginning at the spatter cone the trail winds up to the pit which is hidden from view. After passing other spatter cones the visitor stands at last on the edge of the great pit Halemaumau.

Halemaumau by Day and Night.

There, scarcely one hundred and fifty feet below the observer,[19] is the burning lake perhaps a thousand feet in diameter,—dancing, boiling, and flaring like a gigantic blast-furnace crucible. A dozen or more splendid fire fountains leap from its face and toss the molten basalt into the air. A great gushing lava spring wells up from beneath, pouring out lava steadily, while the fountains round about leap and dance in wild unbridled fury. The heat is often so intense that it is necessary to shield the face to prevent the skin from blistering. The roar of the fiery furnaces is of a solemn, determined, indefinable character, comparable in a way to that made by a heavy canvas flapping in a gale, or to the resistless roar of a storm on a rock-bound coast. Now and then the wind shifts and the fumes of sulphur drive one back from the edge, for breath. Occasionally rocks loosen from their niches in the shattered walls of the pit and go bounding down the sides to melt away in the lake below.

The main body of the lake is usually covered over with large, irregular, broken pieces of solidified lava that float on the liquid beneath like cakes of ice in a river. As the fountains play, waves run out from them in all directions and set the black cakes bobbing about in the lurid flood. Now and then the lava shoots up a hundred feet in the air, and, as the falling discharge strikes the surface again, waves roll across the lake and break, as surf, against the farther wall. The observer is held in a spell of fascination for hours at a time. As the daylight fades the fiery spectacle increases in brilliancy and beauty and becomes more grandly majestic and imposing. The churning, seething mass takes on more lurid, flaming hues, while the opalescent atmosphere over the pit is resplendent with the most delicate ethereal tints that can be imagined. When darkness finally falls the lake becomes as molten gold. Apparently one can look not only into it but through it. The lines between the cooled dark masses

[19] Conditions of December, 1909.

are far more brilliant by night. Though not perceptible to one looking directly into the pit there is a steady column of vapor rising straight over it to high heaven, where, as it cools, a cloud is formed that becomes a pillar of fire by night, visible thirty or forty miles at sea.

The wonderful and varied spectacle produces in some observers a sense of profound reverence and awe, in others a spirit of wild, child-like glee. However, one and all sooner or later grope as in the presence of the Great Unknown and ask for an explanation of the wonders before them, so grand, so bewildering, so terrible to contemplate.

In search of the answer to these questions men of science with delicate instruments now camp day and night at the crater and record Pele's slightest whim in the hope that some day, in some way, the explanation to the ages-old question as to "the cause of the phenomenon of volcanoes" may be gained from Pele herself. For the present the visitor must be content with theories and superficial answers to almost every question.

It is evident, however, even to the most casual visitor, that Pele is in a sullen mood and is at work filling up her great caldera, preparing for an outbreak or an overflow. Every few hours the lake recedes a few feet, only to well up again, swelling each time higher than before. Kilauea is active and nearing the flood tide. Doubtless before the lava rises much higher, the expected and oft-repeated breakdown in the walls of the great mountain will come, and the fiery lake will vanish back into the bowels of the earth just as it has so often done before.[20]

The trip back to the Volcano House is usually an uneventful and silent one for all; even the most frivolous have food for deep and reverent thought.

Side Trips from the Crater.

Those who are able to prolong their stay at the crater will find a number of side trips may be made that will be full of pleasure and interest. Near Kilauea may be seen tree molds formed in the solid lava, which, in remote time, flowed through an ancient koa forest. In time the charred remains of the trees disappeared leaving their casts as great holes in the lava stream. Holes formed in this way may be seen that are from six inches to six feet in diameter, which in some cases are twenty feet deep.

Fossil tree moulds are quite plentiful in several places on Hawaii and appear to have been formed in different ways. In Puna hundreds of these tree moulds stand above the flows, each marking the location of a tree. The living tree was enveloped by the molten on-rushing lava, which quickly cooled about the tree trunk forming a crust. As the wood burned away fresh lava filled the inside of the mould. When the stream flowed on the lava flood receded, leaving the cast in some cases, in others the mould, standing above its surface, forming a forest of tree trunks of stone. The living koa forest a couple of miles beyond the Volcano House will give the visitor a glimpse of these giant

[20] The lake of fire disappeared May, 1913, leaving the pit empty.

trees that were so much used by the old-time Hawaiians in their arts, and that Europeans have found valuable in many was as a substitute for mahogany.

The Road to the Port of Honuapo.

Beyond the crater the road passes by the point Uwekahuna, which is 117 feet higher than the Volcano House and 601 feet above the lava floor of the crater at the lowest point. It was from this spot that the volcano was first described by Ellis. As the traveler proceeds southwestward towards the port of Honuapo he passes close by the series of cracks that opened in the lateral slopes of Kilauea in 1823 and again in 1869 to give forth copious flows of lava. Other flows from Mauna Loa may be seen.

Near Punaluu a large underground stream of water runs into the sea, and the coast line is dotted here and there by fresh water springs that in former times were of value to the natives that lived in this district.

As the road continues from Honuapo into the Kau district it crosses several recent lava flows from Mauna Loa, the eruptions of 1868, 1887 and 1907 having already been mentioned. There the fields of aa, or rough lava, and pahoehoe, or smooth lava, may be studied to advantage, and the wonders of a great lava flow appreciated without leaving the automobile.

The Kona District.

The Kona district is made up of decomposed lava flows. Its soil is rich and where well watered is covered with verdure. There are no rivers of consequence in the district, the water being absorbed by the loose earth before it has time to run far over the surface.

Along the shore line are numerous stone heiaus that are worthy of notice since they have many interesting traditions connected with them. At Honaunau is a famous ancient city of refuge which occupies six or seven acres of the low rocky point on the south side of the little bay. A portion of the structure was destroyed some years ago by tidal waves, though the walls were twelve feet high and eighteen feet in width.

At Kealakekua Bay may be seen the monument to Captain Cook at Kaawaloa, on the spot where he was killed.[21] Napoopoo is on the opposite side of the bay, and it was there the chiefs lived and where Cook's vessels were anchored near the shore. Beside a pond, overlooking the bay of Napoopoo, is the ruin of the famous heiau where the great navigator was worshiped by the Hawaiians as the god Lono. At the head of the bay is a vertical cliff eight hundred feet in height on either side of which recent lava streams have descended. The road from the landing winds around the bay and over the cliff and continues northward to Kailua past the great stone toboggan slide above Keauhou. This portion of the island is rich and well watered and is given over to extensive coffee, sugar and sisal plantations, while the mountains on the slopes of Hualalai are thickly clothed with forests of koa and ohia.

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[21] February 14th, 1779.

At Kailua the traveler may take the steamer returning to Honolulu, having practically completed the circuit of the island.

CHAPTER XIV.

CONDENSED HISTORY OF KILAUEA'S ACTIVITY.

A Brief Chronology and History of Kilauea from the Earliest Records of Its Eruptions Down to the Present, with Dates and Observations on the Condition of the Lava in the Crater of Kilauea and the Pit of Halemaumau.

The following condensed chronology and history of Kilauea and its active pit, Halemaumau, has been drawn from the written testimony of a multitude of observers, and is designed to give some important facts, dates and figures, as a matter of reference, that were not suited to the more popular account of this great volcano.

From the time of the first immigration, under the great Hawaiian Wakea,[1] until the last and only historically recorded explosive eruption at the crater in 1789, when a portion of Keoua's army was overwhelmed, there appears legendary and traditional evidence to prove that Kilauea was many times in active eruption.

In 1823, when first visited by Europeans, the crater was active and was being emptied by a flow to the south which reached the sea in the district of Kau. The lava dropped from 900 feet[2] to a point 1,700 feet below Uwekahuna, the fixed datum point on the highest bluff on the west edge of the crater—the point to which the rise and fall in the lava lake is herein referred.

In 1824 the crater was empty and the bottom left black and smoking. In 1825 it had still farther discharged, but by the end of the year was filling again. By 1829 it had filled up 200 feet higher than when visited by the same observer in 1825.

1832*. After the last date given (1829) the lava rose above the main crater floor of the earlier period, which was some 300 feet below the floor of the crater at present (1913). During the year (1832) the lava sunk again so that fire was confined in the pit 400 feet down.

In January (1832) an earthquake rent the walls between Kilauea and Kilauea-iki. Lava issued from the cracks thus opened and ran into both craters.

In 1834 Kilauea had subsided, and was much the same as when visited by Ellis, who was its first chronicler.

In 1838 the lava was up to near the present level, and all over an area four square miles in extent. During 1839 the crater continued very active, and by the following year the lava lake was one hundred feet higher than in 1832.

In 1840 the crater was vented to the northeast by the Puna flow, which reached the ocean. The lava dropped from 650 to 1,030 feet below the datum point. By 1841 Halemaumau was filling again. Kilauea was visited during the

[1] 140 A. D. [2] 300 feet below the present floor of the crater.
* Years marked by eruptions on Mauna Loa.

PLATE 48. OBJECTS OF INTEREST IN THE CRATER OF KILAUEA.

(For Description of Plate See Opposite Page.)

year by the U. S. Exploring Expedition party. In 1842 the crater was filling, with a dike built up fifty feet above the surface. **1843.*** Unusual activity in Kilauea. The year 1844 saw the large lake [3] overflowing on every side. In 1846 continued overflows had built the floor of the crater up higher than it was prior to the breakdown in 1840. During 1847 the main crater continued much as in the previous year. In 1848 the lake crusted over, and the dome-shaped crust rose two or three hundred feet high in the center; this is the first dome to be noted in the history of Kilauea.

In May, **1849*** the crater was completely emptied by a hidden discharge. The lava dropped from 350 to 1,030 feet below Uwekahuna. During 1852 great quiet followed the eruption, but in due time the crater began to fill again. In **1852*** it showed no sign of sympathy with the Mauna Loa eruption. During 1854 it still remained quiet, but in **1855*** activity returned, and by mid-summer there were many fountains of leaping lava. In October it was less active, and the dome over Halemaumau had fallen in; the lava was about 1,200 feet below the datum point.

By 1856 there was little sign of activity, and during 1857 similar conditions continued; the lake was about 600 feet in diameter. The following year (1858) there was sluggish action in the pit beneath what was the old dome. In 1862 the lava pool in the pit had increased again to 600 feet in diameter.

The year 1863 saw continued and increased activity. During 1864 Halemaumau was 800 feet in diameter with the lava but fifty feet below the crater floor. A cone was then active in the locality now marked by escaping steam to the northwest of Halemaumau. In 1865 conditions were much as in the previous year, but during 1866 a lava flow in the crater two miles in length was reported.

In **1868*** the crater slowly filled up by overflows from the "North Lake" and from Halemaumau, until the whole central portion was considerably elevated. By April the crater was very active. Earthquakes were numerous. Eight lakes were in ebullition in the crater, and were frequently overflowing. The great earthquake of April 2nd threw down fragments of the outer wall of the crater, cracks opened and the lava flowed out, leaving two-thirds of the bottom caved in from one to three hundred feet below the remaining floor, so that the lava dropped from 600 down to 1,200 feet below Uwekahuna, and Halemaumau was emptied in three days. The discharge was at a point thirteen miles southwest of the crater, and reached the ocean in Kau. Kilauea-iki was at this time flooded over its floor with black, shining lava, the first to enter it since 1832.

[3] Halemaumau. * Years marked by eruptions on Mauna Loa.

DESCRIPTION OF PLATE.

1. The "Little Begger"; a spatter cone by the trail on the way to the pit. 2. A tall spatter cone near the northwest edge of Halemaumau. 3. The entrance to Mme. Pele's reception room. 4. Popping corn over heat cracks in the crater. 5. The "Great Crack" which opened in the floor of Kilauea in 1889. 6. The fire-place at the Volcano House—a shrine famous for its hospitality, its history and its past associations. Before it have gathered many of the world's most distinguished men of science.

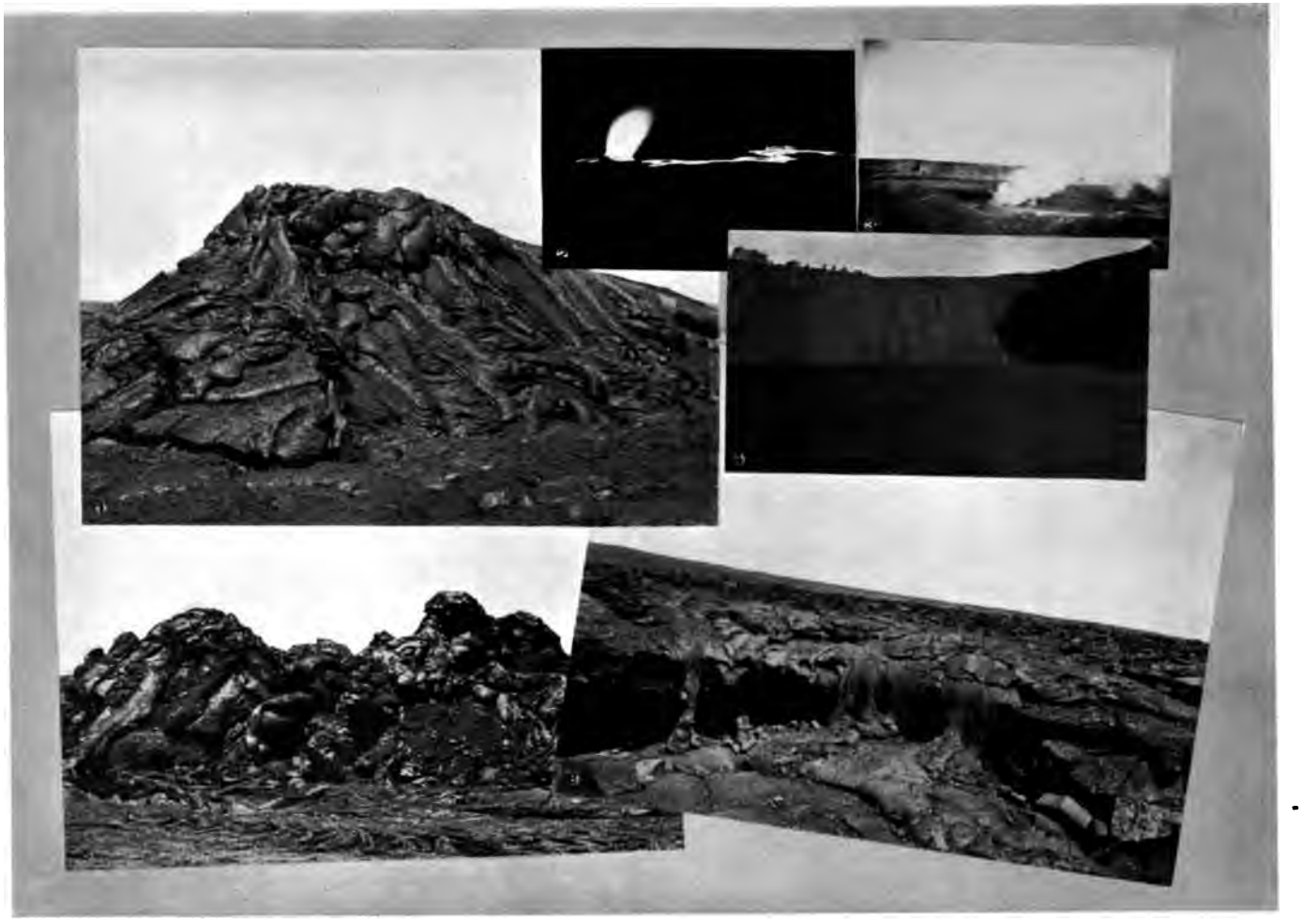

PLATE 49. VIEWS AT KILAUEA AND MOKUAWEOWEO.

1. A bubble dome in Kilauea. 2. Night view of Mokuaweoweo. 3. Day view of Mokuaweoweo. 4. The floor and walls of the pit crater Keanakakoi. 5. Lava mound in Kilauea. 6. Showing a cavern on the floor of Kilauea formed by a caved in bubble into which fresh lava has flowed at a later eruption.

In 1869 lava was seen far down in Halemaumau. Two years later (1871) Halemaumau had filled up to overflowing, and the lava ran two miles to the north over the crater floor. By August the crater was emptied again. In **1872*** Halemaumau again filled and was overflowing, but the action was confined within the black dome, on the summit of which was the molten lake, on a level with the black ledge about the crater, marking the height of former eruptions.

In 1874 the crater, after subsidence, became active again, and four small lakes were reported. During **1875*** two craters developed on the partially-filled floor, to which lava had been gradually added by flows in the crater since the activity of 1868. During 1876 activity in the south [4] and the north lake [5] continued with frequent overflows on the floor of the main crater about them.

By May, **1877*** Halemaumau was empty again. During this year the pit crater Keanakakoi was found to be filled with boiling lava. By September, 1878, both "lakes" in the crater were very active again; several extensive flows from them ran over the crater floor. In the early part of the year 1879 both lakes were active, but on April 21st the bottom dropped out, the lava disappearing within the pit from whence came much vapor and gas. By June both lakes were active again, throwing up jets of lava above the rim of the lake. Later extensive flows occurred on the main floor. On July 15th the sulphur bank in the crater at the south end was set on fire by a flow from Halemaumau. During **1880*** both lakes continued active.

During the period between 1865 and 1880, the outer walls of the crater were found to have completely changed. The floor was now raised in the form of a broad flat dome, the apex of which was but 300 feet below the Volcano House, or 417 feet below Uwekahune; while the lowest point on the floor was near the north wall where the lava was 650 feet below the Volcano House. Throughout the year 1881 both lakes continued active. During 1882 the same general conditions continued with occasional flows on the crater floor. Similar conditions to those of 1882 continued through the year 1883. The "Little Beggar" spatter cone along the trail to Halemaumau was formed on March 31st, 1884. At this time the "new lake" located beyond and to the left of Halemaumau was active. In 1885 it was noted that there had been but little change in conditions in the crater since 1882. The submarine eruption off Puna on January 22, 1884, was attributed to Kilauea. On March 6th, 1886, both Halemaumau and the "new lake" were overflowing. Thirty-six hours later the lava in both had sunk out of sight, leaving a hole 590 feet below the rim of Halemaumau, or 1,017 feet below Uwekahuna, but by the middle of July the lava had returned again.

By August **1887*** lava was overflowing from the edge of Halemaumau. Conditions continued during 1888 about the same as in the preceding years, with the exception that "Dana Lake," a small crater on the west of the main pit, was quite active with occasional overflows. On November 4th, 1889, the very large fissure on the floor of the crater [6] opened without warning. The activity of the

[4] Halemaumau. [5] Called Kilauea. [6] Now spanned by a bridge.
* Years marked by eruptions on Mauna Loa.

previous years at the pit continued throughout 1890 and gradually increased during the year. Early in the year 1891 "Dana Lake" on the west, and the "new lake" on the east of the main pit were in constant ebullition, but on March 7th the lava dropped out of the pit, which "smoked from the bottom." A month later the fire had returned and the lava in the pit continued to rise and fall during the year. By July, 1892, overflows from the edge of the pit occurred and activity continued to the end of the year. Similar conditions continued throughout the year 1893. By March 6th, 1894, Halemaumau, still very active, had built itself up in a retaining wall, formed by the solidification of molten lava splashing over the edge of the pit, until its surface was but 282 feet below the Volcano House—the highest lake recorded in the history of the crater. The floor of the crater had been added to by overflows from the pit during the preceding year.

In July the lava subsided in the pit, dropping 250 feet in ten hours. The fire finally disappeared in December, leaving the pit empty during the following year (1895). On January 3rd, **1896,*** the fire returned, but on January 28th disappeared. It reappeared on the bottom of the pit, 600 feet below the rim, a few days later. After three weeks of very slight activity, it disappeared. The fire returned for three days in June, 1897. In 1898 the pit was estimated to be 800 feet deep.

A breakdown in the walls of Halemaumau occurred in 1900, filling the bottom of the pit. By August 15th, 1901, a like had formed in the floor of the pit. During 1902 the condition of the previous year continued with some variations for several months. At the time the writer made a survey for the model in the Bishop Museum, the pit was 825 feet deep. During **1903*** some slight activity was noted far down in the pit. The crater was quiet during the year 1904, but in 1905 fire was again seen in the pit in March, and slight activity continued throughout the year. The fire disappeared in 1906 leaving the pit 576 feet deep, but in December the pit became active.

By January, **1907,*** the lake was more active, with the lava steadily rising. Later it receded, but by May it had become active again. The amount of fire to be seen varied from day to day, but the lava continued to fill up the pit until during the month of May the pit was estimated to be only 200 feet deep, with the molten lake 800 by 400 feet. In the early part of 1908 the pool continued to rise slowly and irregularly until it was within ninety feet of the level at the edge of the pit. Later the lava receded, leaving a black ledge about the inner edge of the pit. Since that time up to January, 1913, the lava was constantly boiling with varying intensity, and at different levels.

During this long period of activity the crater has been visited by thousands of tourists. Early in 1910 the new automobile road by way of Kilauea-iki was completed into the crater, to a point within one hundred yards of Pele's abode in the inner pit. Many have made use of it in making their visits to her sanctuary.

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* Years marked by eruptions on Mauna Loa.

Natural History of Hawaii.

SECTION THREE

FLORA OF THE GROUP.

CHAPTER XV.

PLANT LIFE OF THE SEA-SHORE AND LOWLANDS.

The plant life of these highly isolated islands has always been a subject of absorbing interest, and much has been done by botanists since the time of Cook's memorable voyages towards putting a knowledge of the flora into an orderly and systematic form. For those who contemplate a serious study of the vegetation of the islands, the important volume of Dr. Hillebrand is, of course, an essential, but for those who wish merely to know something of the more useful, familiar or conspicuous plants, without going into the subject exhaustively, a brief summary of the more salient features may here suffice.

The Island Flora.

We have elsewhere had occasion to refer to Hawaii-nei as being so far removed from the mainland of America and the islands of Polynesia that it is indeed difficult to account for the presence of so varied and extensive a fauna and flora. Nevertheless there is no very tangible geologic evidence, aside from the evidence of a deep subsidence, to furnish ground for a belief that the islands in past geologic time have been more closely connected with other lands than they are at present. We therefore have here, if anywhere in the world, a truly virgin flora—one of great tropical beauty and surpassing interest to students as well as to travelers and holiday seekers who ramble off into the mountains and fields or by the sea-shore in search of change from the common place of the city.

Those who have studied the matter assure us that the nearest land in the Pacific that can be seriously considered as providing stepping stones that may have been instrumental in giving Hawaii her original stock of plants are the Marquesas. But since those islands, like all other lands and islands, are more than two thousand miles distant and are separated from the Hawaiian group by the abysmal depths of the ocean on all sides, the striking physical isolation of the group from adjacent land areas is apparent. Aside from the intercourse that the Hawaiians have had with the groups of islands to the south, an intercourse that undoubtedly resulted in the bringing to the group of all of their more important economic plants as elsewhere stated, the flora of the islands once established, seems to have developed naturally and continuously for a very long period of time. The development seems to have been continued to the present time without the complications that elsewhere result from geologic changes, or other disturbing factors either from within or without.

PLATE 50. VEGETATION OF THE LOWER AND MIDDLE FOREST.

1. Ki (*Cordyline terminalis*); the leaves are still used by Hawaiians as a wrapping for food, fish, etc. In former times a strong drink was brewed from the roots. 2. Typical view

(Description of Plate Continued on the Opposite Page.)

Sources.

Of the movement of ocean currents and their effect as transporting agents, we know but little. Without doubt some plants are transported in this way. As is well known the existing currents in the North Pacific move in a direction that carries them toward the equator from along the shores of the colder American continent. Although Hawaii is in the direct path of this current, few indeed have been the representatives of the North American flora that have been brought to the islands. However, we are not sure that the currents have always had their present motion or direction. It is possible that in by-gone ages, long ago, the movement of the currents of the Pacific may have been reversed, so that various plants from the Australian, Polynesian and South American regions that are well known here, might have been carried to the islands by them, in one way or another.

Number of Genera and Species.

The ability of birds to make long and direct flights is elsewhere referred to and without doubt they have been able to bring a small per cent of the total plant population of the islands. But be that as it may we find the flora of Hawaii remarkable in that, in proportion to the entire number of plants, it has more species that are peculiar to the group than are to be found in any other region of the same area in the world. If we take the total number of plants, including those which have been introduced and have become generally naturalized since the coming of Captain Cook, and include those undoubtedly introduced by the Hawaiians themselves, we have a grand total, for the native and introduced flora, of approximately a thousand species of flowering plants and a trifle over one hundred and fifty species of cryptogamic or spore-bearing plants, making a list, including recent species, of perhaps twelve hundred in all. These are divided by Dr. Hillebrand into three hundred and sixty-five genera, of which three hundred and thirty-five are flowering plants and thirty are cryptogams. It should be remembered of course that this number is being added to and altered and rearranged from time to time, through continued research. It is, however, sufficiently accurate to indicate the character of the flora.

Endemic and Introduced Plants.

If we exclude from the total list as above given those known to have been introduced by the Hawaiians and Europeans we find over eight hundred and

(Description of Plate Continued from Opposite Page.)

in a rain forest. In the Lauhala tree (*Pandanus odoratissimus*) is a bird's nest fern [Ekaha] (*Asplenium nidus*) in its natural habitat. The Ohia (*Metrosideros polymorpha*) trees in the background are overrun with Ieie (*Freycinetia Arnotti*) while in the foreground several genera of ferns can be recognized among them *Sadleria, Cibotium, Asplenium, Aspidium,* and the like. 3. A famous tree fern [Heii] (*Cibotium Menziesii*) surrounded by a jungle of *Sadleria, Aspidium* and other genera of ferns which abound in the moist woods of Hawaii. 4. Wild Bananas [Maia] (*Musa sapientum*) and cultivated Coffee (*Coffea Arabica*) growing in a forest clearing.

PLATE 51. COMMON PLANTS FROM ROCKY COASTS AND SANDY SHORES.

1. Ilima (*Sida spinosa*), a name applied to several related species. 2. Beach Heliotrope (*Heliotropium Curassavicum*). 3. Pickle-weed (*Batis maritima*). 4. Alena (*Boerhaavia*

(Description of Plate Continued on the Opposite Page.)

sixty species distributed over two hundred and sixty-five genera that are to be regarded as the original inhabitants of Hawaii. Of this number more than six hundred and fifty species are found nowhere in a natural state outside of Hawaii and are therefore endemic, precinctive or peculiar to the group.

The number of endemic plants found on the different islands of the group varies in a way contrary to what might naturally be expected, as the number is largest on Kauai and smallest on the large island of Hawaii. This seems to be in accordance with geologic facts. Since, as has elsewhere been said, Hawaii as a whole is regarded by geologists as the youngest of the islands geologically, it is reasonable to conclude that the number of endemic plants occurring on it, or on any of the islands, furnishes a fair index to the relative age of that particular island. Thus Kauai, which stands fourth in area, stands first in her list of species, and the species are as a rule much better defined than are those on the younger islands of the group.

Much that is interesting has been learned by tracing the orgin and affinities of the plants of the Hawaiian group. This is done by carefully following out the relationship of the various genera, families and orders with a view to finding if possible the place from which they have been distributed in times past. Since there are no fossil plants in Hawaii it is necessary to rely entirely on the geographical method of determining the source and relationship of the native flora.

If the two-thirds of the list of the plants that are found nowhere else be left out of account, we find that the remaining one-third has come from various sources, in many instances far remote from the islands, by routes often difficult to trace. On the other hand there are species that are widely distributed throughout Polynesia that are only allied to American forms. Many others are of Asiatic origin with Polynesian affinities. A small number have been contributed by Australia, while a limited number are of African origin. Still other species are almost world-wide in their distribution.

Variation in the Flora from Island to Island.

The plant life of the several islands of the group not only varies as to the character of the flora found on each, but each individual island varies in its flora in different localities to a certain extent, showing adaptations that accord with variations in altitude, soil, wind and the amount of rainfall. This is true to such a degree that no two valleys will have exactly the same plants, and each excursion into the mountains is liable to be rewarded by bringing to light something not seen elsewhere and possibly not even known heretofore in the plant world.

(Description of Plate Continued from Opposite Page.)

diffusa), see also No. 7. 5. Pauohiiaka (*Jacquemontia Sandwicensis*). 6. La Platte Tobacco (*Nicotiana glauca*). 7. Alena (*Boerhaavia diffusa*). 8. Nohu (*Tribulus cistoides*). 9. Akoko (*Euphorbia cordata*). 10. *Maiapilo* (*Capparis Sandwichiana*). 11. Pili (*Andropogon* = (*Heteropogon*) *contortus*). 12. Beach Sandalwood [Iliahi] (*Santalum Freycinetianum var. littorale*). 13. Beach Morning-glory [Pohuehue] (*Ipomoea pes-caprœ*). 14. Beach grass (*Sporobolus Virginicus*). 15. Five-fingered Morning-glory [Koali ai] (*Ipomoea tuberculata*). 16. *Carex sp.* 17. Akulikuli (*Sesuvium Portulacastrum*). 18. Alaalapuloa (*Waltheria Americana*).

PLATE 52. STRIKING PLANTS IN THE HAWAIIAN FLORA.

(For Description of Plate See Opposite Page.)

Hillebrand and others have found it convenient to group the flora of the islands into different zones based mostly on the elevation they occupy. There are six of these arbitrary zones that with a little experience can easily be recognized since their floras are more or less well defined though, of course, intergrading from one zone to another to some extent.

Floral Zones: The Lowland Zone.

For the purpose of this sketch of the flora of the Hawaiian Islands it will suffice to speak of a few of the more important plants in each zone, beginning at the sea-coast, where there is a peculiar strand vegetation, and from there make an ideal ascent of the mountains, taking one zone after another until the summit of the highest mountains have been explored.

Starting with the plants of the lower zone we have species that thrive at the sea-shore, often at the very water's edge. This is known as the littoral flora and always grows along the sea-shore or the margin of brackish water, usually within sound of the sea. It seems to be indifferent to the salt in the soil. Almost all of the plants of this zone are ocean-borne and widely distributed species. As a rule they have fleshy stems and leaves and possess great vitality. They may be uprooted by the waves, borne out to sea by the tides, and carried away for long distances by the currents, to be set out again by the action of the waves on some foreign shore. The plants found growing on Midway, Laysan and Lisiansky, and in fact all the low Pacific islands and shores, are of this littoral type. On Laysan the writer collected twenty-six species that must all owe their origin to the method of transplanting just described.

Common Littoral Species.

There is very little variation in temperature and conditions at the sea-shore throughout the group, and as a result we generally find the condition of plant life fixed and uniform on all of the islands. The same littoral species may occur wide-spread about the shore of the different tropical islands, while the genus to which the species belongs may be represented inland where conditions are more variable by several species, often one or more such species being peculiar to each island where the genus occurs. An interesting example of this is found in the case of the genus *Scævola*—the naupaka of the natives with a wide spread shore species.[1] The species of the genus are all small shrubs bearing white or pale blue and occasionally yellow flowers that are peculiar in that the corolla is split along the upper side to its base. Owing to this peculiarity the

[1] *Scævola Lobelia.*

Description of Plate.

1. Hawaiian Mahogany [Koa] (*Acacia koa*) from the koa forest near the volcano Kilauea. 2. Tree Ferns (*Cibotium sp.*) in the fern jungle near the Volcano House. 3. Lichens on trees; a charcteristic of the forests above 2000 feet. 4. Lauhala (*Pandanus odoratissimus*) by the sea-shore on Hawaii. 5. Staghorn Fern [Uluhe] (*Gleichenia linearis*). 6. A Staghorn Fern tangle near the volcano Kilauea. 7. Wiliwili (*Erythrina monosperma*). 8. Apeape (*Gunnera petaloides*), showing the comparative size of its splendid leaves.

PLATE 53. TWENTY COMMON WEEDS.

1. Cocklebur (*Xanthium strumarium*). 2. False Mallow (*Malvastrum tricuspidatum*). 3-4. Common Sida (*Sida spinosa*). 5. Wild Euphorbia (*Euphorbia geniculata*). 6. Yel-

(Description of Plate Continued on the Opposite Page.)

natives have woven a pretty pathetic story about the blossom which tells of how two lovers, who had long been fond of each other, one day quarreled and parted. As a token of the unhappy event the maiden tore this flower down the side. This was a sign by which her sweetheart might know that she loved him no longer, nor would she care for him until he should find and carry to her a perfect naupaka flower. The lover went in desperation from one bush to another and from one island to another searching through the flowers, hoping to find a blossom that was not torn apart. But alas, he was doomed to disappointment and it is said that he died of a broken heart. That was long, long ago; but the naupaka still blooms always with a slit down the side of the flower, no doubt, as a warning to petulent maidens that it is unsafe to interfere with the laws of nature. Be that as it may, through the long ages since (and longer ages before) this shrub has been blooming on the different islands, and creeping higher and higher into the mountains, and has slowly adapted itself to the changes of soil, elevation and climate until several distinct species and a number of varieties have been formed.

Another characteristic plant of this zone is the sea morning-glory,[2] the pohuehue of the natives. This species with its thick bright green leaves, lobed at the tip, that grow on thrifty creeping stems which root down from the joints, bears dusky pink flowers familiar to every one who has strolled along the sea shore anywhere in the tropics.

A near relative of the above found on the sand beach on lowlands is the native island morning-glory[3] or koali. It is recognized by its heart-shaped leaves and azure blue flowers that become reddish as they fade. The natives used its root in their medicine as a cathartic, and also used it as a poultice for bruises and broken bones.

Associated with these, often growing together with them, is a third species of morning-glory[4] or Convolvulus, the "koali ai." It is found in dry rocky soils near the shore and is recognized by its having the leaves cut into five fingers and its blossoms beautiful purplish-red flowers. It is of more than passing interest since, as the name implies, the natives ate its tuberous roots in times of scarcity. They also wilted and used its stems for coarse cordage. That the natives should use this root as food is not so odd as it at first seems when we remember that the sweet potato[5] or uala, a near relative with more than twenty

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[2] *Ipomoea pes-capræ.* [3] *Ipomoea insularis.* [4] *Ipomoea tuberculata.* [5] *Ipomoea Batatas.*

(Description of Plate Continued from Opposite Page.)

low Wood-Sorrel (*Oxalis corniculata*). 7. False Geranium, "Cheeses" (*Malva rotundifolia*). 8. Sow Thistle [Pualele] (*Sonchus oleraceus*). 9. Rattlebox (*Crotalaria sp.*). 10. Spanish Needles (*Bidens pilosa*). 11. Common Amaranth (*Euxolus viridis*). 12. Stick-Tight Grass [Piipii] (*Chrysopogon verticillata*). 13. Paupilipili (*Desmodium uncinatum* = *Meiobemia uncinatus*). 14. Purslane [Ihi] (*Portulaca oleracea*). 15. Nut Grass [Kaluha] (*Kyllingia monocephala*. 16. Thorny Amaranth (*Amarantus spinosus*). 17. Dog's Tail or Wire Grass (*Eleusine Indica*). 18. Garden Grass (*Eragrostis major*). 19. *Eclipta alba*, common about taro ponds, etc. 20. Crow-foot (*Chloris radiata*). (*No number*) Garden Spurge (*Euphorbia pilulifera*).

PLATE 54. COMMON PLANTS OF THE FIELDS AND ROADSIDE (OAHU).

1. False Koa (*Leucæna glauca*). 2. Kou (*Cordia subcordata*). 3. Hau (*Hibiscus tiliaceus*). 4. Galingale (*Cyperus pennatus*). 5. Mexican Poppy [Puakala] (*Argemone*

(Description of Plate Continued on the Opposite Page.)

varieties, was one of the principle sources of vegetable food used by the natives at the time of the discovery of the islands.

Associated with the foregoing is an interesting plant, the kipu kai,[6] one of two species of heliotrope which occurs on the low littoral zone. As the Hawaiian name implies it is invariably found near the sea. Both species, however, usually grow on the raised coral rock or the dry lava flows rather than the sand of the shore. The pure white flowers are in small compact clusters on a low prostrate, wiry stem. The close rosettes of thick silky leaves distinguishes the second species[7] at once from the smooth-leafed larger form with the longer spikes of white flowers.

Account of the pickle weed (akulikulikai)[8] should here be taken since it is a common and conspicuous plant in brackish water marshes about Honolulu and Pearl Harbor and one that is rapidly spreading to other localities.

Still another plant that is of interest, especially to the small boy, is the nohu.[9] It is sometimes called Mahukona violet by reason of the fragrance of its flowers. The plant is a trailing hairy vine-herb with usually eight pairs of small leaflets to the leaf. The blossoms are yellow and an inch or more across. But the feature of particular interest is the horny seed pods each segment of which is armed with twin spines. The bare-footed boy who steps on one of these pods as it lies buried in the sand is liable to remember the experience for a long time.

A common and interesting species in the lowlands along the shore or at the mouths of streams where the water is not too brackish is the akaakai or bulrush[10] with its long, gradually tapering naked stems, three to six feet or more in height. But there are many plants, sedges and grasses in this zone, common on or near the sea-shore of the group, that are all so widespread in their general distribution that they form a list too extensive to receive mention here.

Such plants as the polinalina[11] with the underside of the leaves and flowers nearly white; the nehe,[12] a low prostrate plant with small, thick, veinless, silky-haired leaves; the beach sandalwood,[13] a low shrub with thick, fleshy, pale green leaves; the maiapilo,[14] a straggling shrub with smooth leaves and large showy many-stamened white flowers; the moa or native cotton,[15] a low shrub with hoary white, three-to-five-lobed leaves and sulphur-yellow hibiscus-like flowers; the pololo or dodder,[16] a leafless thread-like twining parasite, as well as such trees as

[6] *Heliotropium Curassavicum.* [7] *Heliotropium anomalum.* [8] *Batis maritima.*
[9] *Tribulus cistoides.* [10] *Scirpus lacustris.* [11] *Vitex trifolia.* [12] *Lipochæta integrifolia.*
[13] *Santalum littorale.* [14] *Capparis Sandwichiana.* [15] *Gossypium tomentosum.*
[16] *Cuscuta Sandwichiana.*

(Description of Plate Continued from Opposite Page.)

Mexicana). 6. Hinahina (*Heliotorpium anomalum*). 7. Job's Tears (*Coix lacryma-Jobi*). 8. Sedge (*sp. indet*). 9. Mint (*sp. indet*). 10. Bullrush [Akaakai] (*Scirpus lacustris*). 11. Lantana (*Lantana Camara*). 12. Kolu (*Acacia Farnesiana*). 13. Jimson Weed [Kikania] (*Datura Stramonium*). 14. "Opium" tree [Opiuma] (*Inga dulcis* = *Pithecolobium dulce*). 15. Club Rush (*Scirpus palustris*).

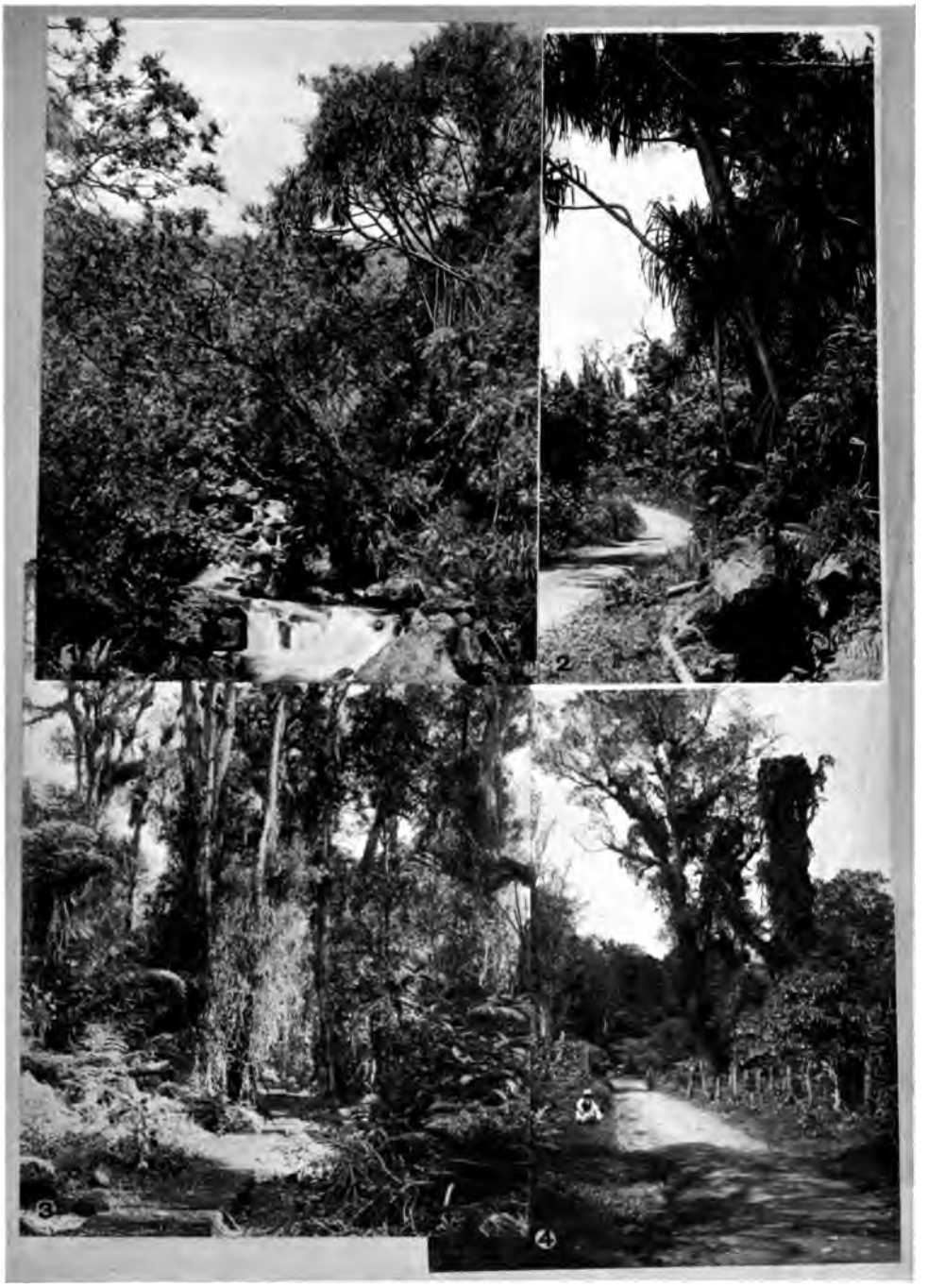

PLATE 55. VEGETATION IN THE FORESTS, ALONG THE STREAMS AND THE ROADSIDE.

1. Typical scene along the mountain streams. 2. On the road to Kilauea. 3. Typical forest jungle in the middle forest zone showing the luxuriant growth of vines. A fern

the milo,[17] niu,[18] kou,[19] kamani[20] and the noni[21] are all liable to occur at or near the strand and to attract notice.

Plants from the Sea-Shore to the Edge of the Forest.

The second zone begins at the sea-shore and extends back to the lower edge of the forest area and reaches up perhaps a thousand feet or more on the slopes of the mountains. This is termed the lowland zone. It is open country, usually covered with grass after a rain, with isolated trees scattered here and there, representing comparatively few genera. Being either arid, sandy or rocky the region nowhere, except possibly in the valleys and along the windward side, produces anything like a luxuriant vegetation. It is in this zone that man has longest had his dwelling and has cultivated, cleared and panted most; therefore since the coming of foreigners and the extension of irrigation and the cultivation of field crops on a large scale the native plants have all but disappeared from this costal or lowland area. They must now be sought in the most unpromising agricultural districts, as about the base of tuff-cones like Diamond Head; or along the lava ledges not accessible to animals; or better still, on old lava flows too rough or too dry for tillage.

One of the most common, persistent and useful of the native trees of this zone is the hau.[22] The tree is very nearly related to the Hibiscus of the gardens from which it can be separated by the fact that in the hau the bracts of the flowers are united to form an eight-to-ten-lobed cup. It is common from the sea-shore to 1500 feet elevation and is a freely-branching tree growing in a snarl, forming almost impenetrable thickets that sometimes completely fill small valleys. It is a favorite tree with the Hawaiians and is frequently utilized as a shade over arbors and lanais. The light wood served as outriggers for the native canoes, the tough bark made pliable rope, and the bark and flowers were used as an important medicine. The flowers are yellow one day and the next day mauve, and according to Hillebrand double blossoms are occasionally found near the sea-shore.

Very closely related to the foregoing is the milo.[23] Like the hau the numerous large, showy yellow blossoms make the milo an attractive tree which often attains a height of forty feet or more. It is somewhat difficult for the novice to recognize the tree as a distinct species. The flower bracts, however, are free and only three-to-five in number, and the seed pods are an inch and a half in diameter, almost as hard as horn, and hang on the tree long after the seeds have ripened.

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[17] *Thespesia populnea.* [18] *Cocos nucifera.* [19] *Cordia subcordata.* [20] *Calophyllum Inophyllum.*
[21] *Morinda citrifolia.* [22] *Paritium tiliaceum.* [23] *Thespesia populnea.*

(Description of Plate Continued from Opposite Page.)

stem corduroy road leads through the Ohia forest which is draped with Ieie vines. To the extreme right and left are graceful tree ferns, while in the foreground are a number of ferns and under-shrubs characteristic of the region. 4. View along the Volcano House road showing a number of introduced plants that have escaped into the forest.

PLATE 56. KUKUI AND COMMON PLANTS OF THE LOWER FOREST (OAHU).

1. Olona (*Touchardia latifolia*). 2. Candle-nut tree [Kukui] (*Aleurites Moluccana*). 3. Hawaiian Moon Flower (*Ipomoea bona-nox*). 4. Ieie (*Freycinetia Arnotti*). 5. Hala-

Description of Plate Continued on the Opposite Page.

Milo occurs generally over the Pacific islands and was formerly much used by the natives in various ways, but especially in making wooden dishes, calabashes and other household utensils. In many parts of the Pacific the tree is held in religious veneration, being planted in or about the native temples, but this does not seem to have been the case in Hawaii.

Two species of native cotton are found in this zone. The one with sulphur-colored flowers is called mao [24]; the one with brick-red flowers is the kokio [25] of the natives. Both species, unfortunately, are rarely met with and the cultivation of either as a garden shrub would be most commendable. In this same region and belonging to the same order [26] as the foregoing are found the four or five species of ilima.[27] They are all low shrubs two to six feet high, with single yellow flowers. The flowers are much prized and have been used for centuries by stringing them together one on top of another on fibers of olona, to make garlands or leis. They are often called the national flower of Hawaii, having long been the favorite flower of Hawaiian royalty.

The ohe [28] is also a tree of this region, and though in no way resembling the bamboo, the latter has been given the same name by the natives. It is a low scrubby, thick-trunked tree fifteen to twenty-five feet high growing on exposed open hillsides and is one of the rarer trees of the region. The leaves are a foot long and bear from seven to ten ovate leaflets. These are lost in the winter, the flowers appearing before the leaves in the spring.

The wiliwili [29] is better known than the foregoing and resembles it in shape and habit. The "coral tree," as it is often called, is to be seen in the city, though unfortunately it is becoming yearly more rare in its native habitat—the open country—where it was formerly a common tree on the rocky hills and plains in the lower open regions on all the islands. The tree rarely grows more than twenty-five feet high and belongs to the bean family, or *Leguminosæ*. It has the trunk and limbs armed with short, stiff thorns. The broad spreading crown of stiff, gnarled, whitish branches bearing bean-like leaflets can hardly escape the attention of the observer; but should it be in flower (its flowers open before the leaves come out) the wealth of red, orange, or yellow blossoms will be a subject of admiration and remark by the merest holiday rambler. The pods are from an inch and a half to three inches in length with from one to several reddish bean-shaped seeds a half inch or more in length. It is not to be mistaken for the tree in parks and grounds bearing the small disk-shaped seed called wiliwili or red sandalwood [30] of tropical Asia, that produces the red lense-shaped "Cir-

[24] *Gossypium tomentosum.* [25] *Gossypium drynarioides.* [26] *Malvaceæ.* [27] *Sida spp.*
[28] *Reynoldsia Sandwicensis.* [29] *Erythrina monosperma.* [30] *Adenanthera pavonina.*

(Description of Plate Continued from Opposite Page.)

pepe (*Dracæna aurea*). 6. Hauhele (*Hibiscus Arnottianus*). 7. Alaalawainui (*Peperomia sp.*). 8. Kopiko (*Straussia Mariniana*). 9. Native Ginger [Awapuhi] (*Zingiber Zerumbet*). 10. Naupaka (*Scævola Chamissoniana*). 11. Koa (*Acacia Koa*). 12. Kalia (*Elæocarpus bifidius*) with diseased inflorescence. 13. Uki (*Dianella ensifolia*). 14. Uhi (*Smilax Sandwicensis*).

cassian seeds'' which are curiosities with travelers and used extensively in Hawaii for leis or necklaces.

The wood of the wiliwili is very light, said to be lighter than cork, and was much used by the ancient Hawaiians for making the float log of the outrigger for their canoes and also as floats on their fish nets.

Another useful plant native to this region, though not well known, is the Hawaiian soap plant or anapanapa [31] which grows to be a large shrub with small greenish flowers.

The only really common flowering plant of the islands among the small forms is the Mexican thistle or puakala. It occurs in dry rocky situations on the leeward side of the islands and grows erect and stiff and from two or six feet in height. It boldly displays the large, attractive white terminal flowers that are three inches or more in diameter. Its flowers are amply guarded with a mass of whitish prickly leaves. Though thoroughly naturalized and found by the first collectors, this thistle-poppy was undoubtedly introduced from the warmer parts of North America.

One of the most characteristic and abundant native trees of the region, however, is the picturesque Pandanus, better known as lauhala [32] or hala by the natives. It is common on the dry plains and about settlements of the lower regions everywhere, frequently growing down on the sand beach. The stout branching trunks and numerous aërial roots growing out of the trunk, as well as the base of some of the branches, are well known peculiarities of the plant. It has long linear leaves crowded into a head at the end of the branches. The leaves are of great value to the natives, since from them they plait the mats, fans, and other articles, elsewhere described, that are so serviceable. The fibrous wood of the old trees is very hard and capable of taking a high polish and in recent times has been used in making the modern turned wooden bowls or calabashes. Picturesque as the lauhala tree is, its principal charm to the natives is in the bright orange-red fruit from which they will continue to string leis so long as there are natives left to wear them. The base of the fruit contains a small, rich, edible nut—about the only native nut in Hawaii worth eating.

The Pandanus occurs widespread over Polynesia. The seeds will stand saturation in sea water for months without loosing their vitality. Hence they can be readily transported by ocean currents and planted by sea waves. In addition to the wide geographical range of the plant, geologists tell us that its ancestors were alive and flourishing in the Triassic period in Europe. It is said to be among the oldest and most persistant of plants, and one that in every way is fitted to take part in the pioneer work of starting plant life on a new-born oceanic island; it is therefore strange that it has not been established in some way on the low coral islands of this group.

In this same lowland zone occurs the Hawaiian dodder or pololo,[33] a species that also extends its range down to the strand. This curious member of the

[31] *Colubrina Asiatica.* [32] *Pandanus odoratissimis.* [33] *Cuscuta Sandwichiana.*

convolvulus family is a golden yellow leafless parasitic vine that begins life as a herb with a twining stem. When it comes into contact with a suitable tree, shrub or vine it twines itself about it, and at the place where it twines about the host plant it develops suckers which sap from the tree all the nourishment the dodder requires for its growth. Finally the roots of the parasite die and the ignoble plant continues to live on its victim much as the mistletoe does. In various places about the group as in Kau on Hawaii, it covers the bushes and the plant growth over hundreds of acres of the low lands.

Introduced Plants.

As has been said, the region from the sea-shore up to and above one thousand feet elevation has been most used by man, and as a result the character of the flora has been changed by many plants, both of native and European introduction, that have here found congenial surroundings.

A noteworthy example of undoubted Hawaiian introduction is the noni.[34] It is a small tree with stout angular branches clothed with thick, smooth, green leaves six or eight inches long by half as broad. The tree is most easily recognized by its curious potato-like greenish fruits. They are fleshy and juicy, but insipid to the taste, and are very fetid while decaying. The noni occurs all over Polynesia from the strands up several hundred feet in the valleys, and in former times was cultivated as a dye plant by the Hawaiians, who secured a yellow dye from the roots and a pink dye from the bark. With the addition of salt they also secured a blue color that was very permanent.

Of the plants that have escaped from European introductions only a few of the more conspicuous or interesting can be mentioned. Next to the lantana perhaps the Verbena or oi,[35] an erect perennial three to six feet high with spikes of small lilac-blue flowers, is one of the most troublesome introductions, especially where large tracts of land are used for pasture. The cassia flower[36] or kolu bean was an early introduction into the islands and grows luxuriantly along the road sides and elsewhere in unproductive regions. Its finely pinnate leaflets and yellow, sweet-scented ball-like flowers are characteristic of this bush, but are no better known to the cross-country rambler than are their sharp needle-like spines. India furnishes tons of the dried blossoms of this plant to commerce, and France, we are told, has plantations devoted to the culture of this or a closely allied species, the aromatic blossoms of which are much used in the manufacture of perfume. Experiments have proven that the quality of the Hawaiian grown flowers, if properly dried, excel in fragrance those grown and cured in India.

Perhaps a dozen species of Acacia are grown in Hawaii, some of which have established themselves in the open. With these should be mentioned several species of the genus Cassia, belonging with their cousin the kolu to the great order of pod-bearing plants[37] that are both wild and cultivated.

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[34] *Morinda citrifolia.* [35] *Verbena Bonariensis.* [36] *Acacia Farnesiana.* [37] *Leguminosæ.*

PLATE 57. CURIOUS NATIVE PLANTS.

1, 2, 3, 6, 10. Showing various growth-forms of common Lobelias on Oahu. 4. Ferns along the "Olympus" trail on the crest of the ridge at the head of Manoa valley; Konahuanui (3105 feet) in the distance. 5. Silversword [Ahinahina] (*Argyroxiphium Sandwicensis*) from Haleakala. 7. Painui (*Astelia veratroides*) at the volcano Kilauea. 8. Silversword, showing the silvery wool on the linear leaves. 9. Ahanui (*Cladium Meyenii*) at the volcano Kilauea.

The nearly related false koa [38] with white ball-like blossoms often an inch in diameter is one that has escaped and become common. Its seeds, known as mimosa seeds, are about the size of those of an apple and are used by the natives in making leis and other ornaments for sale to tourists.

The wild indigo or iniko [39] of the natives growing two to five feet high, with small leaflets in from two to eight pairs to the leaf, is an introduced weed. It was brought in 1836 from Java by Dr. Serriere who, it is said, was able to manufacture a good grade of indigo from it. The species is of American origin, but is now grown in many countries in preference to other indigo-yielding species. This plant is frequently confused with the native plant ahuhu or auholo [40] found growing in the same region and very closely resembling the indigo in size and general appearance. The latter, however, has the flowers and seed terminals on opposite leaves. The pods of the ahuhu are easily recognized, being two inches long and straight, while those of the indigo are a half inch long, much incurved and usually thickly crowded together on the stems.

The ahuhu was much used by the natives for stupifying fish, as the plant possesses a narcotic property similar to that of digitalis. It is said to have a similar effect on the action of the heart.

The common Vinca,[41] a native of tropical America, has escaped in many places and, as about Halawa on Molokai, flourishes on the rocky hillsides in the open country below the forest line.

Black-eyed susans, or Indian licorice,[42] known to some as prayer beads, has also escaped. The plant has leaflets in seven to ten pairs each about half an inch in length. The flowers are pink or pale purple and are followed by pods an inch or so long filled with scarlet seeds, each with a black spot at the base. The plant probably came originally from Asia, but it is now scattered everywhere. Its seeds, like so many other introduced seeds, are worn in Hawaii in the form of leis.

Job's tears,[43] like the foregoing, no doubt escaped from the gardens of the early missionary settlers and found a congenial soil along the water courses, ponds and waste places in the lowlands. The plant is corn-like in appearance, and the large, white, shining fruits have some resemblance to heavy drops of tears, hence its fanciful name. The plant was originally a native of eastern Asia but is now found everywhere in gardens.

With the foregoing should be mentioned the Canna or Indian shot.[44] The common species that has escaped grows along the streams and has been widely scattered about the valleys on the different islands. The flowers are generally red but are frequently yellow and are often variegated as well. The round black seeds are responsible for the English name though the plant is known to Hawaiians as aliipoe. Other species of Canna have escaped, especially on Hawaii, where this genus, which belongs in the same family as the banana, finds conditions especially favorable for its growth.

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[38] *Leucæna glauca.* [39] *Indigofera Anil.* [40] *Tephrosia piscatoria.* [41] *Vinca rosea.*
[42] *Abrus percatorius.* [43] *Coix lacryma = C. lacryma-Jobi.* [44] *Canna Indica.*

Watercress [45] is in reality a species of Nasturtium. It was an early arrival and has spread in the streams about Honolulu and the islands generally. It is the same species as that so much esteemed as a food in Europe. While it flourishes in Hawaii and is especially fine in flavor, it rarely flowers. The air-plant [46] is another escaped plant. It grows two to five feet tall with erect fleshy stems and large, thick, ovate leaves, and has green bell-shaped nodding flowers tinged with reddish yellow. The air-plant is a familiar species in suitable localities of the lower levels. While it is a native of Africa, it flourishes here and is a well known curiosity owing to the fact that a leaf left lying on the table will begin to grow from the crenate notches along its edge, apparently deriving its sustenance from the air.

Grasses.

Grasses of various species, both native and introduced, form the principal field vegetation of the costal region. No fewer than three dozen genera of grasses have been recognized in Hawaii by botanists. Many genera found in the lowlands enjoy a considerable range, extending well up into the mountains, and have numerous species of more or less importance. Of the genus *Panicum* fifteen species and several doubtful varieties have been recorded by Hillebrand and others. They are found in various places under varying conditions throughout the group. At least a half dozen and perhaps more introduced species belonging to this genus are common in the cultivated districts.

The original manienie [47] that formerly occupied the lowlands up to 2,000 feet elevation, belongs to a different genus from the creeping grass introduced in 1835 which is the familiar grass [48] of the yards about the city. The former is a coarser grass creeping with ascending branches six to eight inches long bearing four to eight pairs of leaves. The latter has slender rooting stems, with four to eight pairs of alternate leaves with three to six spikes, an inch or more long, at the end of the stem. Owing to its creeping habit it has been called by the natives manienie. It forms a dense mat in pasture lands and has crowded out other grasses up to the upper limit of the lowland zone. It is of great use in dry, sandy pastures as it binds down the soil and thrives where other grasses fail, since its roots penetrate deep down in the loose soil. Like the algaroba tree, which is a similar fortuitous introduction occupying this zone, it is a most valuable acquisition to the island flora from every point of view.

Two species of Paspalum occur in this zone; one, the well known and generally despised Hilo grass,[49] occurs in moist, heavy soils in the lower zone and grows well into the higher regions in suitable places. The Hilo grass, which is an introduced species as has been said, has crowded out almost every other species of grass where it has gained a foothold. It is a large, rank grass, taller than the native species, growing two to four feet high, and has two spikes at

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[45] *Nasturtium officinale.* [46] *Bryophyllum calycinum.* [47] *Stenotaphrum Americanum.*
[48] *Cynodon dactylon.* [49] *Paspalum conjugatum.*

the top of the stem, a peculiarity separating it at once from the smaller species [50] having three to six alternately arranged spikes.

The well known pili grass [51] is an important species in this zone, as is also the kakonakona.[52]

Two plants formerly commonly grown in the lower zone by the Hawaiians were their calabash and bottle gourd vines. The calabash gourd [53] is a prostrate climber with lobed leaves and large yellow flowers bearing large depressed globe-shaped red, green or yellow fruits, sometimes two feet or more in diameter. While the original country from which this useful gourd came is unknown, it was common in Hawaii at the time the islands were discovered by Cook, but does not seem to have been known in the rest of Polynesia until after the coming of the white man. As has elsewhere been explained, the hard shell of the ipu nui was made use of as containers for food, water and clothing.

The bottle gourd [54] differs from the foregoing in having the leaves undivided, the flowers white and the fruit elongate, often measuring four feet or more in length. The ipu grows on a thrifty musk-scented vine that was largely cultivated by the natives of most tropical countries and, unlike the ipu nui, it was well known all over Polynesia. The hard, woody shell of the fruit served as war masks, bula drums, containers (as water bottles) and in many other ways in the household and general economy of the primitive inhabitants. One of the ingenious arts of the ancient Hawaiians was the ornamentation of these gourds. The gourd to be ornamented was first cleared of the seeds and pulp and then coated on the outside with a thin layer of breadfruit gum, which made it impervious to water. With a sharp instrument, usually the thumb nail, the gum was carefully removed from the part where the pattern, which varied greatly in design, was to show. This done the ipu was buried in taro patch mud for a considerable period. When the color of the soil had become thoroughly set in the shell of the gourd, it was taken from the water and the remaining gum removed, leaving the desired design in two shades of rich brown indelibly dyed in the shell.

The Lantana,[55] which belongs in the lower zone, extends its range in many localities up to the three thousand foot level. The common cactus,[56] or panini, is the prickly pear of Hawaii, and is common in this region, especially on Oahu. Two species of ilima occur in the lower zone throughout the group. Their bright yellow flowers, so much used in leis, are well known to every one. The smaller species [57] is a low shrub, usually with ovate, hairy leaves, and differs from the second species [58] which usually has heart-shaped ovate leaves that are hairy below and greenish above. Both of the foregoing have the leaves rounded at the base, while a third species [59] has the leaves broadest about the middle.

In the open edge of the forests, or occasionally descending far down into the lower zone, the ohia lehua [60] is first met with. The ohe [61] seldom reaches

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[50] *Paspalum orbiculare.* [51] *Andropogon contortus.* [52] *Panicum torridum.* [53] *Cucurbita maxima.*
[54] *Lagenaria vulgaris.* [55] *Lantana Camara.* [56] *Opuntia Tuna.* [57] *Sida fallax.* [58] *Sida cordifolia.*
[59] *Sida rhombifolia.* [60] *Metrosideros polymorpha.* [61] *Reynoldsia Sandwicensis.*

the lower forest, while its companion on the fore hills, the wiliwili,[62] seldom reaches the thousand-foot level; but the bastard sandalwood,[63] while it reaches the upper limit of vegetation on the highest mountains, may also occur well down into this lower zone, thus exhibiting a great vertical range in habitat.

CHAPTER XVI.

PLANT LIFE OF THE HIGH MOUNTAINS.

Passing now from the lowland zone to the lower forest zone, we find it tropical in appearance. Though not sharply defined it is by common agreement said to begin at about one thousand feet elevation and to extend as a belt about the high mountains up to about three thousand feet.

Plants of the Lower Forest Zone.

The range of the kukui [1] is almost confined to the limits of the lower forest zone, and since it is the most abundant and conspicuous tree of the region, it is regarded as the characteristic tree of the lower forests. The pale green foliage of this useful tree sets it out in marked contrast with the darker greens, and adds a touch of variety to the Hawaiian forest that delights the eye of the beholder. The plants of this region are larger and more thrifty than those of the costal plain, and being more numerous the open sylvan character of the zone is well defined.

The ki [2] (now commonly written ti)is at home on the steep valley sides and in the gulches, at the lower edge of the forest zone all over the islands, and, indeed, through all Polynesia, the Malayan Archipelago and China. Specimens fifteen feet in height, with leaves from one to three feet in length and three to six or more inches in width, are not uncommon. The ki belongs to the lily order and the leaves are peculiar in having many parallel nerves diverging from a short mid rib. The large saccharine root was made use of in ancient times by the natives in making a curiously flavored beer. Later they learned a method from the sailors of distilling a strong, intoxicating drink from the soaked roots. The ki root was baked by the Hawaiians in their imus (underground ovens, elsewhere described), and eaten by them as a confection; it was their substitute for candy, now so generally eaten by all peoples. The ki root prepared in this way is very sweet, much like molasses candy; it is offered for sale in the market in Honolulu every Saturday. Among other uses, a stalk with the leaves attached served as a flag of truce in native warfare, and the juice of the plant was used by the Hawaiian belles to stiffen their hair. The leaves, known as la-i or lauki, served and still serve as wrapping. And, since the coming of domestic animals, the plant has proved useful as fodder.

Closely related to the ki or ti, belonging to the same order in fact, is the curious halapepe or cabbage tree,[3] sometimes called a palm lily. Its chief interest lies in the fact that it helps to give the foliage that weird character which is expected of tropical verdure. The plant is the largest of the order

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[62] *Erythrina monosperma.* [63] *Myoporum Sandwicense.* [1] *Aleurites Moluccana.*
[2] *Cordyline terminalis.* [3] *Dracæna aurea.*

to which it belongs, often growing twenty-five feet or more in height. It prefers the bold, rugged valley slopes and is a marked tree wherever it occurs. Its thick trunk branches freely and roots are sent out above the ground, so that the tree very much resembles the lauhala in this respect. The leaves, which are two feet or more in length, are born in crowded tufts at the ends of the branches, leaving the trunk and stem rough with leaf scars and marks of slow growth.

The botanical name *Dracæna*, meaning a 'she dragon,' was given the genus to which the Hawaiian species belongs because of the dragon's-blood resin of commerce which exudes from the bark of certain species, a character shown to some extent by the sap bark of the native species. The old-time Hawaiians carved some of their hideous idols out of its soft, white wood.

Another plant peculiar to the lower woods, that extends its range far beyond the line arbitrarily assigned for the upper limit of the zone, is the ieie,[4] a climbing shrub with many of the habits of its cousin, the lauhala. It needs no introduction to the forest rambler. Climbing over the tallest trees or trailing on the ground, it often forms impenetrable thickets. The rigid stem is about an inch in diameter with numerous climbing and aërial roots. The stiff rough leaves, from one to three feet long, are crowded into a tuft at the ends of the stems. The male flowers are on two to four cob-like cylinders five or six inches long by less than an inch in diameter and are surrounded by a whirl of rose-colored leaf bracts. They are among the more showy blossoms of the woodlands. From the pendant roots the natives formerly made ropes of great strength and durability.

It is usually at about this elevation that the koa[5] is first met with, though it does not attain its maximum size and importance as a forest tree until well up in the middle forest zone. Hillebrand recognized two closely related species and several varieties; while the cabinet makers, basing their classification entirely on the character of the wood, recognize a dozen or more as curly koa, red koa, yellow koa, and so on, all of which are collectively called Hawaiian mahogany, owing to the superficial resemblance which the wood bears to that well-known cabinet material. Mahogany, by the way, is a native of Central America and the West Indies, and belongs to an entirely different order of plants, of which the introduced Pride of India is an example, but an order of which there are, so far as known, no representatives in the native flora.

The koa is a tree of rare beauty with its laurel-green, moon-shaped, leaf-like bracts. The tree often attains a height of sixty to eighty feet, with enormous trunks frequently six to eight feet in diameter, and with wide-spreading branches. Canoes seventy feet long were made of a single trunk; it was in such canoes that Kamehameha the Great made his conquest of this group and contemplated using them in a war-like expedition to the Society Islands two thousand seven hundred miles distant.

In addition to the many uses made of the wood by the natives in making canoes, calabashes and the like, it has long been esteemed as one of the choice

[4] *Freycinetia Arnotti.* [5] *Acacia Koa.*

PLATE 58. PLANTS OF THE OPEN FIELDS AND LOWER FORESTS ON OAHU.

1. Hoawa (*Pittosporum glabrum*). 2. Mamake (*Pipturus albidus*). 3. Kamole (*Jussiæa villosa*). 4. Lobelia [Ohia wia] (*Clermontia macrocarpa*). 5. Akoko (*Euphorbia malti-*

(Description of Plate Continued on the Opposite Page.)

cabinet woods. Combining as it does a rich red wood, with a beautiful grain that is susceptible of a high polish, it is much used in the manufacture of furniture and as an inside finishing wood in public buildings. The bark is also of use in tanning leather.

Botanically the koa belongs to the genus *Acacia* of which fully half of the known species are Australian, while the rest are scattered widely over the world, many having been introduced into Hawaii.

Examples of the native Hibiscus occur, but they are rather rare plants. Four species are known; the flowers are all single and are pink,[6] white,[7] yellow[8] and red[9] respectively. One with ovate leaves and white flowers, often growing twenty-five feet tall, is found in the mountains back of Honolulu and occasionally on the other islands. All of the native species have been held in cultivation as garden shrubs and much has already been done along the line of producing new varieties by cross polinization. A closely allied genus, *Hibiscadelphus,* has been recently established to include three rare species found on Maui and Hawaii.

The native Smilax[10] is by no means the tender hot-house plant one might be led to expect. On the contrary, it is a robust climber with stems a third to a half inch in diameter and fifty feet in length that trail across the forest path. The leaves are three to five inches long and broadly ovate, having a width in proportion. They are easily recognized as they are dark glossy green and have five to seven parallel nerves running lengthwise of the leaf. The natives know this striking vine by various names—uhi, ulehihi and pioi being among them. It is said that they formally ate the tuberous roots in times of scarcity.

Another attractive vine of the lower forest zone is the hoi or yam.[11] The scattering large, broad, heart-shaped leaves are five to seven inches long and have from seven to eleven nerves converging towards the tip. It is a plant of wide distribution, extending its range as far as Africa. To the botanist it is of peculiar interest because of the large potato-like bulbs, called alaala by the natives, that grow here and there at the base of the leaves. The large, irregular, fleshy roots of the yam were much used as food by the natives, and formerly were cultivated to supply ships calling at Hawaii before the common potato was introduced.

The native ginger[12] is a conspicuous and to a certain extent characteristic plant of this zone. Growing one or two feet high with leaves six or eight inches long, and bearing a pretty pale yellow flower on a curious cone-like inflorescence,

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[6] *Hibiscus Youngianus.* [7] *Hibiscus Arnottianus.* [8] *Hibiscus Brackenridgei.* [9] *Hibiscus Kokio.*
[10] *Smilax Sandwicensis.* [11] *Dioscorea sativa.* [12] *Zingiber Zerumbet.*

(Description of Plate Continued from Opposite Page.)

formis). 6. Plantain (*Plantago major*). 7. Fleabane or Horse-weed [Iliohe] (*Erigeron Canadensis*). 8. (*Solanum triflorum*). 9. Indigo [Inikoa] (*Indigofera Anil*). 10. Wild Ipecac [Nuumele] (*Asclepias Curassavica*). 11. (*Carex Oahuensis*). 12. Painter's Brush (*Composite* Family). 13. Kaluha (*Kyllingia obtusifolia*). 14. Lobelia (*Rollandia calycina*) young. 15. Popolo (*Solanum aculeatissimum*). (*No number*) = *Lythrum maritimum.*

PLATE 59. THE MAILE AND ITS PLANT ASSOCIATES ON OAHU.

1. Maile (*Alyxia olivaeformis*). 2. Akoko (*Euphorbia clusiaefolia*). 3. Kapana (*Phyllostegia grandiflora*). 4. Composite (*Sp. indet.*). 5. *Phyllostegia sp.* 6. Ground Pine

(*Description of Plate Continued on the Opposite Page.*)

the awapuhi often entirely covers the ground in the lower forests. The natives made no use of the horizontal, fleshy root stocks, but the slimy juice from the inflorescence, being "as slippery as water off an eel," was used by the beauty-doctors of a former time as a dressing for the hair. This substance, as also the juice of ki, and the sap of the hau tree mixed with poi for use in cooling the skin, were three of the chief cosmetics to be found on the dressing table of the Hawaiian belle. The Chinese ginger[13] of commerce is occasionally grown in the islands in a limited way by the orientals. A number of other species are also grown as ornamental plants.

Kauila,[14] or the more widely ranging form[15] known by the same native name, was one of the useful woods of old Hawaii. By reason of its remarkably close, heavy grain it was especially useful in making spears, kapa beaters, and other tools and implements. The second species mentioned was formerly fairly common on the lower slopes of all of the islands, where it formed a tree fifty to eighty feet high with alternate, parallel-veined hairy leaves, and small terminal flowers.

The uulai,[16] a low, much-branching, stiff shrub with small leaflets and small white inconspicuous flowers which were followed by whitish roseapple-like fruits, was used for making arrows for the toy bows used in killing rats.

The ohia,[17] or ohia lehua, though growing best in altitudes where rain is more abundant, is common and one of the characteristic trees of the lower forest zone. From about 1,500 feet elevation to at least 6,000 and even 8,000 feet, it is an important and abundant tree, to be seen in every landscape. Often it forms dense shaded forests where the trees are festooned with vines and the ground is carpeted with moss and ferns. In such localities trees four feet in diameter and nearly one hundred feet tall are occasionally seen. Unfortunately the root system of this important forest tree is very shallow, often spreading over the surface of the hard soil beneath. As a result they are especially liable to be blown down in the high winds and heavy storms of the higher forest zones. Its wood is very hard and durable, but warps badly. With the coming of the whites it was used to some extent in the framework of their houses and as fence posts. More recently its hard and durable wood has been found to make very excellent railroad ties, street-paving blocks, and it is also much used as a hardwood flooring in dwellings.

The ohia occurs on many of the important islands of Polynesia, and its many and intergrading forms long puzzled the native botanists, and it is only fair to say that their European friends have by no means satisfactorily disposed of the

[13] *Zingiber officinale.* [14] *Colubrina oppositifolia.* [15] *Alphitonia excelsa.*
[16] *Osteomeles anthyllidifolia.* [17] *Metrosideros polymorpha.*

(Description of Plate Continued from Opposite Page.)

[Wawae iole] *Lycopodium cernuum*). 7. Limu Koha (*Hepatica*). 8. Hepatica. 9. Hawaiian Mistletoe [Kaumahana] (*Viscum articulatum*). 10. *Nertera depressa.* 11. Wawae iole (*Lycopodium pachystachyon*). 12. *Cyrtandra sp.* 13. *Budleya asiatica.* 14. Oha wai (*Clermontia persicæfolia*). 15. Papala (*Pisonia umbellifera*). 16. Kaawau (*Ilex* = (*Byronia*) *Sandwicensis*). 17. *Lycopodium serratum.*

problems of classifying the many forms that under varying conditions occur on every island in Hawaii. They may be either trees or shrubs with leaves opposite or alternate, smooth or rough, round or linear, with flowers axillary or terminal, red or rarely yellow; in short any plant in the forest, about which there may be any doubt, is liable to be an ohia or an ohia lehua, though lehua is generally and more correctly the name of the beautiful blossoms which are composed mostly of clusters of the red pistils and stamens.

Of these flowers the natives are both fond and proud. Few indeed are the mountain climbers that do not return at nightfall decked out with garlands of the sweet-scented maile [18] and bearing a lei of the beautiful lehua to the never-forgotten ones at home.

It is about the modest maile vine that the sweetest perfume and the fondest memories linger. It is of the maile that the voyager first hears as he lands in the islands of sunshine and smiles. It is for the maile that he learns to seek on his day-long rambles in the mountains, and it is a braided strand of maile thrown about his neck at the fond parting by the shore that tells with its fresh breath of the enchanted forest, in an enchanted land, and with its lingering caress brings the dew of human tenderness to the eyes of the one departing. And at last it is the faint perfume from a withered half-forgotten keepsake,—a maile lei, that, though the oceans, and half a life time may intervene, will set the heart throbbing and make the eyes grow dim at the memory of the fond aloha that it breathes, calling the wanderer back again to the happiest of lands.

The straggling, somewhat twining, inconspicuous maile shrub is common in the woods of the lower and middle regions and is recognized by the elliptical, smooth, oval leaves from one to two inches in length; by the flower which is small and yellowish and by the elliptical, fleshy, black fruits that are more than half an inch long. The maile lei is made from the finer stems which are broken off and the bark removed from the wood by chewing the stems until it will peal off readily. The perfume is not noticeable until the bark has been bruised in this manner.

The ohia ai,[19] the mountain apple, or edible ohia, belongs to a different genus,[20] but in the same family as the true ohia. Frequently clumps of the mountain apple will occur surrounded by ohia or kukui, especially at the foot of cliffs, and besides the mountain waterfalls. It is a tree from twenty to fifty feet in height with large green leaves and red flowers followed by refreshing, crimson fruits that grow from the trunk and main branches.

The awa [21] is best known owing to the intoxicating drink the Polynesians manufactured from the large, thick, soft woody roots of a plant of the same name which was cultivated by the natives of the various groups of islands of the Pacific. The plant often grows two to four or more feet high, bearing large, alternate heart-shaped begonia-like leaves six inches long by more than that in width. It thrives in Hawaii and was always planted by the natives in

[18] *Alyxia oliviæformis.* [19] *Eugenia Malaccensis.* [20] More properly *Jambosa.* [21] *Piper methysticum.*

the moist valleys of the lower zone. The plants were carefully cared for and the roots when gathered were used either fresh or dried. To make the drink the root, which is astringant to the taste, was first chewed and thoroughly mixed with saliva. It was then put into a wooden bowl and a quantity of water added. After it had stood a short time the liquid was strained off; it was then ready for drinking. The effect was that of a narcotic and invariably produced stupification if taken in any quantity.

Native Fiber Plants.

The natives formerly cultivated several other plants in the lower forest zone. Olona [22] was one of the most important of these. The plant grows best in regions of great rainfall, usually in the wet forests on the windward side.

The olona plant is a low woody perennial, with a viscid juice, seldom growing more than a dozen feet in height. It has large ovate leaves, often a foot in length and proportionately broad. The genus is a Hawaiian one with but a single species, but botanists tell us that it belongs to the same order as the ramie,[23] which is grown in many places as a fiber plant. The fiber, "olona," is contained in the bast of the stem and is remarkably fine and straight and is entirely free from gum.

In former times every chief had an olona plantation somewhere in the mountains, as the fiber from the wild plants was not used to any extent. In raising the crop the ferns were carefully cleared away from about the patch to give the plant all the strength of the soil. The old plants were broken or rolled down to allow the young shoots to grow straight and rapidly. When of sufficient size the crop was cut, stripped and hackled by the use of crude implements and allowed to dry and bleach until such time as the fiber was white and ready for use. Being resistant to the action of salt water it made fine rope, seines and fish lines. Certain of the natives formerly paid their taxes in olona, and it was always regarded as a valuable possession.

The paper mulberry or wauke [24] of the natives has a milky sap and is a small tree with ovate leaves. The leaves are either entire or three-lobed and usually from five to seven inches long, dentate along the edges and roughened on the upper surface. The use and culture of the plant has been explained elsewhere. It is now to be met with growing in clumps here and there through the lower open portions of the forests. Wauke is to be distinguished from the mamake,[25] which is a low shrub seldom over ten feet high, with flowers in axillary clusters, that was also used in the manufacture of tapa. Mamake has the ovate leaves three to four inches long, and the sap always watery and the flowers unisexual. The leaves vary greatly in several respects, but generally are whitish beneath. The species seems to be unknown outside of this group.

Sandalwood.

That portion of Hawaiian history which tells of the discovery of sandal-

[22] *Touchardia latifolia.* [23] *Boehmeria nivea.* [24] *Broussonetia papyrifera.* [25] *Pipturus albidus.*

PLATE 60. PLANTS OF THE MOUNTAINS AND ALONG THE SHORE.

(For Description of Plate See Opposite Page.)

wood [26] in the islands, and the events which led to its being almost wiped out as a forest tree as a consequence of its great value in commerce, may properly be sketched here, since the iliahi furnished the first article of export which attracted commerce to the islands. Sandalwood is still occasionally found at rare intervals and in out-of-the-way places in the lower forest belt on all of the islands, though the range of the several imperfectly-defined varieties and species extends the distribution from near the sea shore up to as high as ten thousand feet on Maui, where the species [27] becomes a low dense shrub, six to ten feet high.

The delicately scented wood is from a tree usually growing from fifteen to twenty-five feet high with opposite ovate to obovate leaves two and a half to three inches long by about an inch and a half in width, which are somewhat thickened and perhaps ochraceous underneath. The flowers occur as small terminal and axillary inconspicuous cymes.

The sandalwood trade began about 1792, the first authentic mention of it being made by Vancouver. It is thought that the knowledge of there being sandalwood in the islands was an accidental discovery by one Capt. Kendrick and that the wood was probably brought to his vessel with other timber as fire wood. From this time on the development of the business was rapid until in 1816 it had developed into an important industry among the natives, chiefs and foreigners. Between 1810 and 1825 the trade was at its height. The wood was at first sold in India, but later the market shifted to Canton, where the large pieces were used in manufacturing fancy articles of furniture and in carvings, and the smaller pieces made into incense.

For export the green wood was cut in the mountains into logs three or four feet long. These varied from two to eight inches in diameter. The logs were carried on the heads and shoulders of the natives to the shore where they were sorted and tied into bundles weighing one hundred and thirty-three and a half pounds each. While green and wet the wood has no aromatic smell, but when dry the odor is powerful and impregnates the whole atmosphere.

The bundles of sandalwood were eagerly purchased by American traders for export. The business flourished to such an extent that it is reported that during the height of the industry three hundred thousand dollars worth of sandalwood was exported in a single year.

The king, as well as many chiefs, engaged in this profitable business on their own account. At about this period each man was required to deliver to the

[26] *Santolum ellipticum.* [27] *Santalum Haleakalae.*

DESCRIPTION OF PLATE.

1. The crest of the Mapulahu-Wailau trail, Molokai (3151 feet). showing the character of the growth in the rain forest. 2. View from near the summit of the Palolo trail, Oahu; a typical mountain scene. 3. An Ieie (*Freycinetia Arnotti*) jungle on Oahu. 4. Typical view of the vegetation on the mountain ridges of Oahu. 5. A mountain path, showing a natural graft between two neighboring Ohia trees. 6. View showing the bog flora at the head of Pelekuku valley, Molokai. 7. Sand beach, showing Pohuehue (*Ipomoea pes-caprae*) trailing down to the water's edge.

PLATE 61. OHIA AND SOME OF ITS PLANT ASSOCIATES ON OAHU.

1. *Kadua sp.*, one of many Hawaiian species. 2. Ohia (*Metrosideros rugosa*). 3. Ohia ha (*Syzygium* = (*Eugenia*) *Sandwicensis*). 4. Tall Ohelo (*Vaccinium penduliformis var.*).

(Description of Plate Continued on the Opposite Page.)

governor of the district in which he lived one-half "picul" of sandalwood or else pay four Spanish dollars.

The drain on the supply was enormous. It was not uncommon for lumbering parties of three hundred or four hundred people to go into the mountains. On Hawaii, Ellis relates that he saw two or three thousand men returning from the forest, carrying sandalwood for shipment tied on their backs with ki leaves, each one carrying two or three pieces. Even the roots were dug up in many places. As early as 1831 the business was on the decline, and by 1856 the wood had become very scarce. By 1835 the government recognized the danger of exterminating the valuable trees and steps were taken to prevent the cutting of the young wood. But according to the historian Dibble credit must be given to Kamehameha I for being the first to attempt to conserve the supply of this valuable wood. It is related that the men cut the young as well as the old trees, and that some of the small trees when brought to the shore attracted the great warrior's attention. "Why do you bring this small wood hither?" he inquired. They replied, "You are an old man and will soon die, and we know not whose will be the sandalwood hereafter." Kamehameha then said, "Is it indeed that you do not know my sons? To *them* the young sandalwood belongs."

Nevertheless, the drain on the forests continued until only an occasional tree was left here and there on the more rugged and inaccessible heights, and even these have suffered from the attacks of wild goats, which find its bark especially toothsome.

It is said that the odor of the Hawaiian sandalwood is inferior to that from Malabar, Ceylon, and certain parts of India. The fragrant wood, called laau ala by the natives, is quite heavy even after the sap has dried out. It is then a light yellow or pale brown color, and retains the scent indefinitely.

While the sandalwood was the most important among the Hawaiian plants producing pleasant odors, it was by no means the only one. There were many others whose flowers, fruits, leaves, sap, bark, wood or roots furnished perfume. The most highly scented of all are the seed pods of the mokihana [28] used in making leis. They are much esteemed as they retain their perfume when dry and hard. The best specimens of this plant, as of almost all the scented varieties of native plants, come from Kauai. For temporary adornment, the leaves and blossoms of wild ginger or awapuhi,[29] the drupe of the lauhala or screw pine,[30] the leaves of the maile [31] and the fronds and stems of several species of ferns, especially the palapalai [32] (a highly scented species) were all used because

[28] *Pelea anisata.* [29] *Zingiber Zerumbet.* [30] *Pandanus odoratissimus.* [31] *Alyxia olivæformis.* [32] *Microlepia strigosa.*

(Description of Plate Continued from Opposite Page.)

5. Naupaka (*Scævola mollis*). 6. Kokolau (*Campylotheca sp.*). 7. Akoko (*Euphorbia clusiæfolia*). 8. Hoawa (*Pittosporum spathulatum*). 9. Kopiko (*Straussia Kaduana*). 10. Naenae puamelemele (*Dubautia laxa*). 11. Ohia lehua (*Metrosideros polymorpha, var.*). 12. *Metrosideros polymorpha var.* 13. *Metrosideros polymorpha var.* 14. *Metrosideros tremaloides.* 15. Naenae (*Dubautia plantaginea*). 16. Alani (*Pelea clusiæfolia*) with tree snail attached to the leaf. 17. *Syzygium* = (*Eugenia*) *Sandwicensis* with deformed inflorescence.

of their pleasing odors. The scent of the lipoa,[33] a sea moss, was also used as a perfume. Cocoanut oil, scented with sandalwood, was used to some extent on the hair and body.

The bastard sandalwood or naieo[34] is a tree common on the summit of Kaala, and the higher forest belt generally, that becomes fragrant on drying and has an odor that resembles sandalwood. After the exhaustion of the sandalwood it was exported to China for a time as a substitute for that valuable wood. The naieo is found dead in many localities at as low a level as 1,500 feet.

In the lower forest region, on Oahu especially, occurs the pretty white-flowered napaka[35] in the form of low shrub. The heads of the valleys in this region are usually marked by clumps of wild bananas,[36] of which there are many varieties, and various species of the interesting and curious Lobelia first appears, and ferns of many species abound.

A marked difference exists in the nature of the flora of this zone on the windward or wet and the lee or dry side of the islands, and the student of plant life soon learns that there are many floral districts in this zone, each of which usually has its characteristic species of plants.

The Middle Forest Zone.

The next important area is usually designated as the middle forest zone and extends up the mountains from three to six thousand feet elevation. It is well marked by the greatest luxuriance in tree and jungle. As it is within the region of mist and clouds, it is well watered and furnishes conditions in every way suited to plant growth. It is in this zone that the native Hawaiian flora finds its fullest development. The tree ferns, the giant koa, the ohia and kamani forests are the predominating species. Though none of these larger and more important growths are wholly confined to this region, it is here that they reach their maximum of size and development.

On visiting the region one is impressed at once by the number and variety of ferns to be found in this zone. Probably the most important among them are the giant tree ferns, the hapu[37] and hapu ili[38] and the smaller amaumau[39] being the most striking. The hapu with trunks that are from a few inches to three feet in diameter and often fifteen to thirty feet in height are especially abundant about Kilauea and there reach their greatest development. Their plume-like fronds are often fifteen feet or more in length, giving the top a spread of more than twenty-five feet. The native name hapu has been applied to two or three closely allied species. But with the commercial importance the tree gained a few years ago through the use made of the soft, glossy, yellowish wool at the base of the young leaves, these and other large ferns have come to be known as pulu ferns, pulu being the name of the wool-like fiber from the fern. The fiber was used to some extent in stuffing mattresses and pillows, and in a

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[33] *Haliseris plagiogramma.* [34] *Myoporum Sandwicense.* [35] *Scævola Chamissoniana.*
[36] *Musa sapientum.* [37] *Cibotium Chamissoi.* [38] *Cibotium Menziesii.*
[39] *Sadleria Souleytiana* on Oahu; *S. pallida* on Hawaii, and *S. cyatheoides* on all islands at lower elevations.

small way as a surgical dressing in cases of excessive bleeding. The old-time natives made use of it in their crude attempts at embalming. Human bodies buried in dry caves and elsewhere if wrapped in pulu were liable through absorption by the pulu to dry out or mummify.

Giant Ferns.

Like several other species these giant ferns spring up again from the fallen trunk, particularly in the damp and congenial atmosphere of the middle forest. It is a common sight, along the volcano road, to see the fern stems used for walks and fences continuing their growth, by means of lateral shoots. But space is not sufficient to enumerate all or even the more interesting ferns. Botanists recognize twenty-two genera and at least one hundred and forty good species, more than half of which are confined to the islands. The great majority ot these are found most abundantly in the middle forest zone of the different islands of the group.

A species of considerable interest is the pala fern.[40] It grows with glossy dark green leaves three to five feet long rising from a thick fleshy root stock. This latter abounds in starch and a mucilagious substance so that when cooked in the native fashion it made a very good food and was much used by the natives in times of scarcity.

The bird's-nest fern or ekaha [41] belongs to a large genus that is a widespread form of which there are forty species in Hawaii. The English name is therefore rather loosely applied to any species of the genus. They are common on the trunks and in forks of trees in the forests where they are striking and curious objects resembling birds' nests in many ways. They are much cultivated in the city where specimens with leaves four feet long and eight inches wide are to be seen.

The common brake, kilua or eagle fern,[42] is everywhere common on all the islands from eight hundred to eight thousand feet elevation, especially on rocky ridges. The species is broken up into many varieties and occurs in one form or another all over the world. The roots of this fern were never used for food. The wild pigs, however, are very fond of them and often turn up great patches in the mountain in search of the roots, thus doing much damage to the forest. The maiden-hair fern or iwaiwa [43] is found in the wet gulches, particularly about waterfalls on all the islands. The black, glossy stems of this fern and also of the larger closely allied species,[44] known under the same name by the natives, was for a time used by them in making hats and baskets, several specimens being preserved in the Bishop Museum.

A conspicuous and serious impediment to travel in this region are the tangled, forked fronds of the common uluhi or staghorn [45] or one of its two other closely allied species. The polished brown stem, little larger than a slate pencil, often grows six feet or more high, forming a tangle that may extend for miles along the ridges in the whole of the forest zone up to three or four thou-

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[40] *Marattia Douglasii.* [41] *Asplenium nidus.* [42] *Pteris aquilina.* [43] *Adiantum capillus-Veneris.*
[44] *Pteris decipiens.* [45] *Gleichenia dichotoma.*

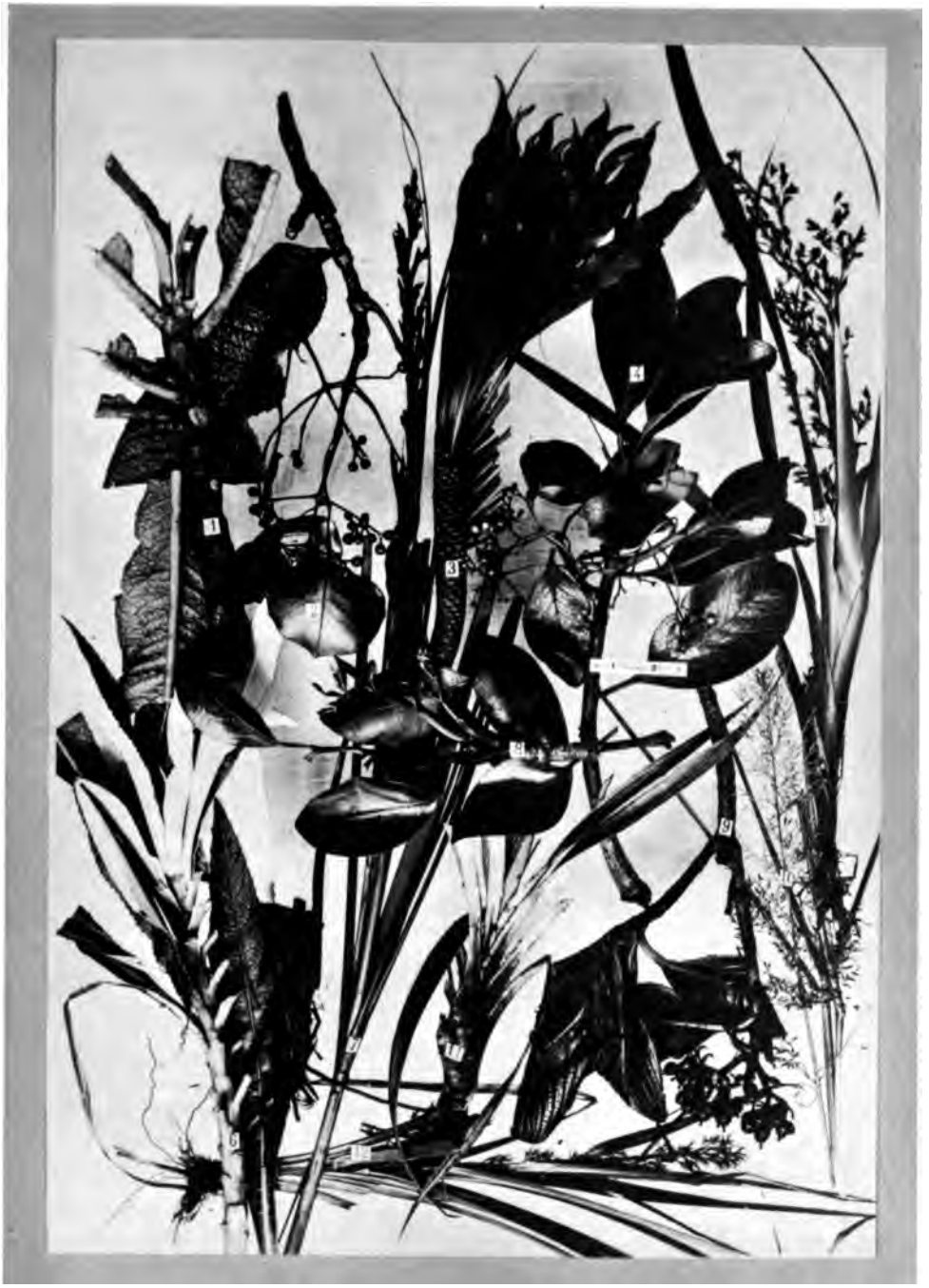

PLATE 62. PLANTS FROM NEAR THE SUMMIT OF KONAHUANUI, OAHU.

1. Species of Lobelia (*Rollandia calycina*) adult. 2. Lapalapa (*Cheirodendron platyphyllum*). 3. "Kahili" Lobelia (*Cyanea angustifolia*). 4. Kawau (*Ilex* = (*Byronia*) *Sand-*

(Description of Plate Continued on the Opposite Page.)

sand feet elevation. The stems are so tough and have the fronds so locked together that they often form a barrier through which it is most fatiguing to force one's way.

The enormous rhubarb-shaped, thick, rough leaves of the apeape,[46] three to five feet across, are occasionally to be seen by the more hardy mountain climbers who visit the Waianae Mountains and the higher mountains on the other islands of the group. The leaves are the largest of any plant in Hawaii and are said to be the largest of any of the dozen or more species belonging to the genus *Gunnera*. Nearly the same name (ape or apii) was applied by the natives to a plant [47] that grows on dry land in the lower zone. The latter plant belongs to the taro family and is a native of India, but has long been naturalized and cultivated in Polynesia as a substitute for taro and is generally known in Hawaii as dry-land taro. It is remarkable for the strong, sickening smell of the flowers.

The ohelo,[48] described in the chapter on fruits, is common in the high mountains of this zone, and its shining, fleshy berries, famous in native song and story as an offering to Pele, are also delightful for their slightly astringent, but cool and refreshing flavor. They are much enjoyed by those who visit the region in which they grow.

A much-branching shrub of the region, growing from three to six feet high with very small, stiff thick leaves, is known as the Christmas berry or puakeawe.[49] It is one of the most characteristic plants of the islands, particularly of the higher mountain regions. The minute white flowers are followed by small red, or red and white berries. The berries and leaves do not readily fall and for this reason it is increasing in favor for use in Christmas decorations.

The Hawaiian mistletoe [50] is a curious parasitic plant of the forest belt that is found growing quite commonly on the koa and ohia branches, securing its substance entirely from the host plant.

The Hawaiian representatives of the order *Lobeliaceæ* is one of the most interesting and characteristic groups of plants in the whole island flora. They are herbs, shrubs and small trees, all with woody stems and a milky juice. More than sixty species are now known, belonging to six well-defined genera which differ widely in appearance. The majority, however, are tall and shrub-like with simple undivided trunks, and of somewhat palm-like growth owing to the fact that they have rough scars on the trunks to mark the attachment of of discarded leaves. They are without doubt survivors of an ancient flora which has been superseded by other forms, and doubtless we have at present only a

[46] *Gunnera petaloidea.* [47] *Alocasia macrorrhiza.* [48] *Vaccinium reticulatum.*
[49] *Cyathodes Tameiameiæ.* [50] *Viscum articulatum.*

(Description of Plate Continued from Opposite Page.)

wicensis). 5. Ahaniu (*Cladium* = (*Baumea*) *Mcyenii*). 6. Typical Lobelia (*Lobelia hypoleuca*). 7. *Gahnia beecheyi.* 8. Ohe (*Tetraplasandra meiandra*). 9. Kanawau (*Broussaisia pallucida*). 10. Emoloa (*Eragrostis variabilis*). 11. Painui (*Astelia veratroides*). 12. *Rhynchospora thyrsoidea.*

remnant of the species that once flourished in our mountains. The natives recognized their striking form and beauty and gave names to most of the species. One of the commonest names is oha wai, which is applied indiscriminately to species of the more abundant genus *Clermontia*. They are known to modern Hawaiians as plants from which the old-time bird-catchers made a sticky glue for capturing birds. Oahu has perhaps twenty-five species, and as many more sub-species and varieties of these interesting plants, that are about equally divided among five of the six Hawaiian genera.

An important forest tree that extends its range from two to eight thousand feet elevation, often becoming the dominant tree in extensive areas on Kauai, Maui and Hawaii, is the native mamani.[51] It grows from twenty to thirty feet high, with six to ten pairs of obtuse, rich-green leaflets to each leaf. The pale yellow flowers are followed later with long straight pods four to six inches long. The hard wood has proved valuable as fence posts.

The foregoing, together with the bastard sandalwood or naio,[52] and several species of shrub-like trees[53] with yellow flowers, are found growing up to and giving character to the upper limit of the forest zone; in some places reaching an altitude of ten thousand feet above the sea.

Enough has been said to indicate the tropical luxurance of this zone; but the ferns, lobelias, creeping vines, lichens and mosses, all form an undergrowth that is varied, striking and interesting. The middle zone, however, is primarily the region of the native forest.

Of the native woods there are upwards of two hundred species, of which over one hundred are well known forms. The list, as well as the total list of Hawaiian plants, has been somewhat extended through the exploration of Mr. Forbes and others who have been active in this field recently. The majority of the trees are met with in the lower and middle zone. The whole forest region is distinctly tropical in character, since none of the familiar trees of the temperate zone are present. The new-comer from America looks in vain for the oaks, the elms, the maples, the spruce and the pine. In their stead he finds the forest trees dominated by the koa, ohia, mamani and kukui, and that these are combined with koaia,[54] kopiko,[55] kolea, naio, puu,[56] and a long list of equally conspicuous trees that occur in almost every landscape.

Perhaps one of the most accessible and in many ways interesting regions in this zone is that found about the volcano Kilauea. The most casual observer is there impressed with the size and beauty of the tree-ferns that occur in such profusion in that locality; but the botanist will find a rich field filled with many interesting species. Up to a hundred years ago the forests were only limited by the natural conditions of rainfall, elevation and lava flows. Since the coming of the whites there have been many causes as elsewhere enumerated that have been at work bringing about a change in the natural conditions. Chief among the disturbing elements, however, have been the cattle. As early as 1815 they

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[51] *Sophora chrysophylla.* [52] *Myoporum Sandwicense.* [53] *Raillardia.* [54] *Acacia koaia.*
[55] *Straussia* spp. [56] *Olea Sandwicensis.*

were recognized as a serious menace to the native forests. Roaming at will through the forests they and other animals, as goats and pigs, have done untold damage, and brought about conditions that have been most serious in many places. It is only in recent years that they have been fenced out of the forest and their number reduced so as to more nearly correspond with the beef requirements of the islands.

The Upper Forest Zone.

The plant growth of the upper forest zone begins at about five or six thousand feet above the sea and extends as high as eight or nine, and in some instances, ten thousand feet. It is made up for the most part of more or less stunted representatives of the trees, vines and shrubs met with in the middle and lower zones. There are, however, a number of species found in the higher altitudes which do not descend even into the middle zone.

The akia,[57] a name applied to several species with small leaves and flowers in terminal and axillary clusters that are followed by orange-colored fruits, is well represented in this zone; although species of the genus are first met with in the lower woods. It was used by the natives as a fish poison in much the same way that the awa and ahuhu were used. Its strong flexible bast-fibers were also used in many ways.

The pilo,[58] a large diffuse shrub four to eight feet high with small, ovate, thick leaves with nerves impressed on the upper surface, is also represented here, and is one of the several species of the genus to be met with throughout the forest area. The shrub naenae, a species of *Dubautia* with opposite lanceolate leaves four to eight inches long and small orange-colored flowers borne in loose panicles, also has much the same distribution as the preceding genus.

Conspicuous composites of which several species and varieties occur in various altitudes are especially common in the upper forest zone under the name kokolau,[59] a name applied generally by the natives to all the species. The genus, with a dozen species, is purely Hawaiian and is closely related to the Spanish needles of the lower levels. The plants grow from two to five feet high and in many places cover large patches of ground with the warm yellow color of its blossoms. The flowering plants of the region are mostly peculiar to Hawaii, but the ferns which become more and more scarce as the upper limit of the forest is approached are those that belong to the wide-spread forms, such as the owalii,[60] kaupu[61] and a few similar species belonging to the high mountain flora.

The Silversword.

The native strawberry, and the ohelo mentioned in another connection, are also found in the upper forest zone. The distinct flora of the higher mountains, well above the cloud belt, is affected more or less by snow and frost. The species of the region are comparatively few in number. The most interesting

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[57] *Wikstroemia* spp. [58] *Coprosma* spp. [59] *Campylotheca* spp. [60] *Asplenium Trichomanes.*
[61] *Aspidium aculeatum.*

PLATE 63. COMMON GENERA OF FERNS ON OAHU.

1. Amaumau (*Sadleria cyatheoides*). 2. Uluhe lauuui (*Gleichenia longissima*). 3. Okupukupu (*Nephrolepis exaltata*). 4. (*Microlepia tenuifolia*). 5. *Asplenium sp.* 6.

(Description of Plate Continued on the Opposite Page.)

and unique species in its aspect, perhaps, is a composite belonging exclusively to the higher elevations known as the silversword.[62] In its general appearance it might be related to almost anything more nearly than the sunflower and the chrysanthemums to which botanists make it next of kin. Its stout, woody flower stem, two or three inches in diameter and several feet high, is surrounded at the base by a dense head of slender, rigid, dagger-like leaves, eight to sixteen inches long, that are covered with white glistening silvery hairs. The flower heads are large and striking, objects much admired by mountainers. The securing of a specimen of the ahinahina, or of a second closely related species known as the green silver-sword,[63] from their home on the high mountains of Maui and Hawaii, seven to twelve thousand feet above the sea, is a feat that even as yet but comparatively few have performed.

In Hawaii the gathering of a silversword corresponds with the gathering of the edelweiss in the Alps, and furnishes the adventurous climber a prize well worth keeping as a memento of a trip that invariably costs much in exertion if not in actual peril.

Another plant peculiar to the region is one of the half dozen species of the shrubby Geranium, or nohuanu of the natives. The leaves are usually covered on both surfaces with silvery hairs like the species just mentioned, but unlike them they are small and the flowers are regular and red or white in color.

The Mountain Bog Flora.

Leaving these few plants and their less striking associates struggling for existence at the limit of vegetation, we now return to consider for a moment the most unique of all the Hawaiian flora, that which belongs to the mountain summits and table lands that are almost perpetually concealed in clouds at an elevation of approximately 5,000 feet. Strange as it may seem, here and there about the group are several curious mountain bogs that are nearly destitute of shrubby plants of any size, but are clothed with a mat of grass, sphagnum moss and sedges, together with a number of interesting plants of small size whose near relatives are natives of the mountains of New Zealand, the Southern Andes and the Antartic regions. It has been suggested that they represent the survivors of an ancient flora that has been crowded out by the arrival of new plants. Whether it is that, or some equally interesting and significant fact in distribution will doubtless long remain open to discussion. The occurrence in such a locality of several species of violets is remarkable to say the least, but a more curious

[62] *Argyroxiphium Sandwicense.* [63] *Arygroxiphium virescens.*

(Description of Plate Continued from Opposite Page.)

Kaapeape (*Asplenium pseudofalcatum*). 7. *Asplenium sp.* 8, 9, 10. *Cibotium* showing the development of a fern frond. 11. *Asplenium contiguum.* 12. sp. indet. 13. Peahi (*Polypodium spectrum*). 14. *Aspidium sp.* 15. Kilau (*Trichommanes davallioides*). 16. Staghorn Fern [Uluhe] (*Gleichenia linearis*) = (*Gl. dichotoma*). 17. Wahine noho mauna (*Polypodium tamariscinum*). 18. *Asplenium erectum.* 19. Ekaha (*Elaphoglossum* = (*Scrostichum*) *comforme*).

fact is that some of them grow on upright and other on procumbent, creeping stems three to five feet in length. These familiar sweet-scented flowers, together with the moss and lichens, the stunted, creeping kolokolo kuahiwi [64] and maieli or pupukeawe [65] combine to form one of the most striking and interesting provinces in the flora of the whole group.

But it is not to be expected that all the interesting and remarkable forms in the plant life of the islands could be touched upon in a few short pages. Only a few have been mentioned; but omissions cannot be wondered at, as the largest books on the subject leave much that is interesting unnoticed and often fail to give the information that one would wish about even the common trees and plants.

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[64] *Lysimachia daphnoides.* [65] *Cyathodes Tameiameiæ.*

Natural History of Hawaii.

SECTION FOUR

THE INTRODUCED PLANTS AND ANIMALS OF FOREST, FIELD AND GARDEN.

CHAPTER XVII.

A RAMBLE IN A HONOLULU GARDEN: PART ONE.

To anyone coming to the islands from the more rigorous climate of the mainland, the verdure to be seen in Honolulu is little short of a dream of paradise come true. In many ways the city of Honolulu appears as a great tropical botanical park, conducted on a coöperative plan, the advantage being that the residents, as shareholders in the enterprise, have their homes dotted about here and there over the spacious well-kept lawns. The houses, covered as they are with vines and surrounded with luxuriant foliage, add to the picturesque beauty of it all, so that more than one person has been heard to exclaim, "This Pacific Paradise is indeed the land of heart's desire."

First Impressions of Honolulu.

It is not too much to say that from the morning of the day of one's landing after a weary sea journey to the very hour of their departure, be it in a day, a year, or a life time, the rare tropical trees and plants to be seen on every hand, but especially in Honolulu, furnish a source of never-ending pleasure and delight.

If one has an interest in plant life, it is a rare treat to be brought face to face for the first time with living examples of such symbols of the tropics as the breadfruit, the cocoanut palm, or the banana. One is made to feel that no picture has ever done justice to such visions of beauty as they often present in their natural setting, and the observant person is at once alive with interest, anxious to know something of the multitude of interesting and curious trees and plants with which these conspicuously tropical species are often grouped. The visitor is always keen for a ramble through any of the attractive gardens that abound on every hand and anxious to know more of the wonderful exotic flora that embowers the thrifty island capital.

Perhaps the first general observation in this connection is one made from the deck of the steamer as it rounds Diamond Head and reveals Honolulu as a city, not built on a hill, but hidden beneath a canopy of waving green trees that are so large and dense that only the tallest buildings and spires can be seen

above the tree tops to serve as a guarantee that beneath the wealth of green lies one of the most cosmopolitan and beautiful cities in the world.

As one walks or rides about the streets he observes that so far as the flora is concerned Honolulu may be said to be simply a very good reproduction of the Kew gardens of London, the difference being that in tropical Honolulu the gardens are done on a very large and elaborate scale. In most instances, in both places the plants that one sees are not native to the country but are those that have been brought hither from the very ends of the earth and set growing for the interest, the benefit or the pleasure of those who know how to enjoy them.

The streets of Honolulu are often narrow and winding, but most of them, even the very broadest, are shaded by various species of trees that reach out from the yards on either hand. Often great trees will be left in the center of the sidewalk and occasionally the street itself is divided by some fine specimen that has been allowed to stand, by an appreciative and public-spirited road overseer.

Palms.

Palms are to be seen in great variety and abundance. Of the more than seventy species occurring everywhere about the city all but two or three are foreign to the islands. The most conspicuous and stately among the introduced species is the royal palm.[1] It was brought to the islands long ago from its home in the West Indies. Planted singly, in straight avenues or in irregular groves, it is an attractive tree that cannot fail to arrest the eye, since it everywhere gladdens and enriches the landscape. Their lofty, clean, grey trunks are absolutely vertical and as symmetrical as though turned in a lathe. No scar of growth or blight of disease mars their marvelous straight Ionic shafts up to the crowning tuft of long, beautiful balanced, pinnate leaves of deep shining green that form fitting capitals for such splendid stately pillars. The slightest stir of breeze sets every leaf waving and singing, and night and day one knows "when the wind is in the palm trees" by the gentle rustle that they make.

The blossoms are small, sweet-scented, cream-colored flowers that hang in a great pendant cluster from the base of the lowest leaves. Their faint odor is a pleasant one in the soft balmy evening, and by day a source of great concern to swarms of busy bees that reap a rich harvest of honey during the few days that the blossoms last. At length the blossoms are followed by the fleshy fruits that are eaten by the mynah birds, and by them the seeds are carried from place to place.

A Falling Leaf.

I well remember with what surprise and alarm I first heard a palm leaf fall. It was in the still of the night soon after my arrival in the islands. Scarcely a breath of air was stirring when suddenly I was aroused with a start at hearing, somewhere in the garden, a mighty ripping noise that ended abruptly

[1] *Oreodoxa regia.*

in a loud cracking sound as though a whirlwind hda broken loose among the tree tops. Then followed a swirl and a swish, a rustle, and a rush that seemed to leave no doubt but that all the trees in the garden had been suddenly set whirling through the air. But after a moment of breathless suspense the whole affair ended in a terrific clatter and thump, after which all was again as silent as before. In the morning when the leaf was shown to me there remained no doubt but that it was the cause of the "cyclone" of the night before. The leaf was a trifle over eighteen feet in length and weighed several pounds! Though accustomed to regard a falling leaf as an exceedingly melancholy thing, I had never before thought of the harm that might be received in the tropics a least, from so simple and ordinary a thing as having a withered leaf strike one unawares as it circled gracefully to the ground.

The Cocoanut Palm.

The cocoanut palm [2] is perhaps native, or at least of very early introduction by the natives, and is among the most showy of the palms. It is the cocoanut palm by the sea that first greets the stranger on his arrival in Hawaii. Basking in the languid warm sunshine it has stood for generations at the post of honor by the broad portal of this earthly paradise. Breathing the very spirit of the tropics it has come to be the symbol of true hospitality and stands ever ready to cast that magical spell that none can resist. At the parting it is this stately sentinel by the water's edge that is always the last living thing to reluctantly wave a fond good-bye to those who must depart, knowing in their heart of hearts they are to return again.

Its feathery plumes tower out above everything else, as they are often sixty feet or more in height. All things considered there are indeed few trees among the wild, semi-cultivated or exotic flora in Hawaii that equals in picturesque beauty this "the prince of palms."

Few trees so frequently and effectively figure in the domestic setting for the Honolulu home. They are of fairly rapid growth and come into bearing, in favorable soil, in ten or fifteen years. The tree continues to grow in height until thirty or forty years of age, when they seem to have attained their limit of growth, but they continue to live on indefinitely without gaining materially in size or height. On the beach at Waikiki are trees that are known to be several hundred years old, while a splendid grove near by has very nearly caught up with them in height in a single life time. This palm will never branch and never sends up shoots from the ground, and like many other trees in the tropics that belong to a great group known as Endogenous plants, they are easily killed by destroying the plume-like top.

The cocoanut trees thrive best at or near the sea-shore. However, they do reasonably well in some localities two or three miles inland. Elevation apparently has more influence in retarding growth than the absence of the effect of the sea. Where water is to be had in abundance any soil seems to do so long as it is

[2] *Cocos nucifera.*

PLATE 64. VIEWS IN TROPICAL GARDENS IN HONOLULU.

1. A by-path in the tropical gardens at Ainahau showing Crotons (*Codiæum variegatum*) in the foreground; to the left farther on the Umbrella plant (*Cyperus alternafolia*). Festooning the cocoanut trees are several species of *Philodendron*. 2. Lily pond at Ainahau. 3. Date Palm drive in Kapiolani Park.

easily penetrated by the roots of the palm. For this reason the sandy soil near the sea-shore furnishes its best environment. The structure of the tree fits it to withstand wind of almost any force and they seem to prefer plenty of rain, wind and sun.

The yield of nuts fluctuates greatly from year to year and from tree to tree. There are reports of as many as 400 nuts having been gathered in one season from a single tree in some of the more favored islands of the south Pacific. In Hawaii as many as 200 nuts, besides innumerable blossoms, have been counted on a tree at one time, but it is doubtful if an average of eighty mature nuts could be gathered during a year. It is a curious thing that nuts perfectly green in appearance will be as ripe as those having yellow husks. For this reason, it is desirable to pick the oldest nuts on the tree without waiting for them to ripen and fall to the earth. While no one in Honolulu, to my knowledge, has ever been injured by a falling cocoanut, the constant danger from that source is apparent since a good-sized nut in the husk weighs several pounds. Those who are familiar with the delicate flavor of the young nut prefer to gather them when half mature and spoon the soft meat out of the shell before it has had time to solidify and become oily.

Of late years the tree rat has become a great pest in the cocoanut trees and does great damage to the young nuts by gnawing holes in them. They readily pass from one tree to another along the leaves, and when a colony of rats becomes established in a grove the tin sheaths so commonly placed about the trunk of the tree does but little good, unless the tops of the trees are kept clear of the neighboring foliage.

While it is considered a difficult thing to tell how the milk gets into a cocoanut, the rate of growth and the remarkable changes that take place during the period of germination and early growth when the milk is getting out of the nut can be easily studied and well repays the trouble of making the observation. The time occupied in germination varies greatly, owing to a number of conditions, especially the amount of moisture and sunshine, but in general many weeks must pass before the first leaf opens.

Just how the cocoanut came to Hawaii in the first place will never be known. Its legendary history dates far back, and doubtless the tree has accompanied the Polynesians on all of their wanderings about the Pacific. To this day the native country of the cocoanut is not definitely known. DeCandolle finds twelve reasons for thinking it of Asiatic origin, but singularly enough there is one reason—an almost unsurmountable one, for believing it to be an American plant. Botanists have proven that none of the other nineteen species of the genus exist anywhere in a wild state except on the American continent, and therefore conclude that the familiar species must have had the same origin. Some say that the Philippine Islands is its ancesteral home, and that it was from thence carried in all directions by ocean currents or by artificial means. At any rate it ranges over the whole of the tropics, and within that range there are many varieties based mainly on the size and shape of the fruit. However, these variations are

strongly marked and retain their characteristics when grown from seed. For the reason just stated we may regard those grown in Hawaii—at the northern limit of the range—where the climate is scarcely warm enough for their best development, as forming a fairly distinct variety, namely the Hawaiian cocoanut.

The cocoanut, or niu, had many uses in Hawaii a century ago. The trunk of the tree furnished fairly heavy timber, while the long pinnate leaves were used in former days as thatch, and laced together they formed the walls of the native lanai. From the husk of the nut a durable rope was made, and various household utensils were manufactured from the shells. The natives drank the juice and ate the meat of the nuts. They also healed their wounds with a balm made from the juice, and with the oil extracted from the meat of the nut they anointed their limbs and embalmed the bodies of their dead.

The Date Palm.

Less striking, perhaps, but even more beautiful in certain ways than the foregoing, are the date palms[3] with their splendid fronds that are often larger and always more numerous than are those of the cocoanut palm. To many these sturdy, thrifty trees are the symbol of strength, beauty and repose.

The date palm was long ago introduced into Hawaii and it has been a conspicuous tree in the islands ever since. Though it bears large bunches of orange-colored dates, the fruit is seldom eaten, as the pits are usually so large that the little flesh that surrounds them is not worth the effort required to secure it. Without doubt, however, a good quality of dates can be produced here, when suckers are secured from selected parent plants.

The leaves of this and other species of palms are often used for decorations, especially on Palm Sunday. It is thought that for this reason the parent plants were of very early introduction into the new world by the Spanish missionaries.

Ornamental Palms.

The betel nut,[4] though with a very slender stem, is in superficial appearance not unlike the royal palm. It bears a yellow fruit, the size of a hen's egg which has one seed surrounded by a fibrous husk. The seeds are chewed by the natives of certain south Pacific and East Indian islands to blacken the teeth. The word betel is erroneously applied to this fruit, as it is the name of the leaf of a totally different plant.

Of the native palms a few specimens of the loulu palm are to be seen here and there about the city. They are a fan palm with smooth trunks and in their wild state grow in secluded places in the forests often to an elevation of three thousand feet above the sea. One species, the loulu lelo,[5] has small ovid fruit, while the loulu hiwa[6] has large globulur fruits. Of the innumerable varieties of fan palms to be seen only a word can be said, since their number and variety defy a brief characterization. However, the class can be easily recognized by

[3] *Phoenix dactylifera.* [4] *Arcea catheeu.* [5] *Pritchardia Gaudichaudii.* [6] *Pritchardia Martii.*

their fan-shaped leaves. The more common, though less attractive wine palm,[7] can at once be recognized owing to its large coarse bipinnate leaves and wedge-shaped leaflets that are strongly toothed at the extremities. The wine made from this palm in India is drawn off by cutting the ends of the flowering stems from which exudes the sweetish sap. This is then boiled down into a syrup or by fermentation made into a toddy. The splendid examples of the Washington palm,[8] with their tall robust trunks clothed with the pendant remains of dead leaves, are sure to attract attention from travelers, especially those from California, where this "weeping palm" is a native.

Two or three species of the beautiful Rhapis palms occur in the islands, where they are usually planted in pots and tubs. They are one of the few palms that produce suckers at their base, thereby forming thick clumps. The large species[9] often grows eight or ten feet in height and has the stems armed with prickles. The smaller species[10] most commonly have the stems unarmed and the leaves with about ten segments. It can easily be identified as a different species from the plants having leaves with from five to seven segments.[11] All of the species are native to Japan and China and are occasionally called Japanese or Chinese palms.

Other plants of interest are the sugar palm,[12] a spineless species growing forty feet high; and the oil palm,[13] with a stout coarsely and deeply-ringed stem twenty or thirty feet high. It has red fruits which yield the palm oil of commerce. The bottle palm,[14] with a curious bottle-shaped stem or caudex, and the blue palm,[15] with splendid bluish fan-shaped leaves, are easily recognized.

Only two or three species of the tropical palm-like cycads are found here, and these are the common kinds to be seen growing under glass in more rigorous climates. The plants are propagated from seeds. They are very curious in their method of flowering since the flowers appear in a mass in the heart of the great crown of leaves. In time the flowers are followed by the fertile seed from which they readily grow. The sago palm[16] is the commonest species in cultivation, though the much larger species[17] is not uncommon.

ARAUCARIA.

Passing to the evergreen-like trees, the giant Araucaria of Australia and elsewhere grows to an enormous size and is frequently seen in gardens. Some splendid species of the Norfolk Island pine[18] are to be seen in the older gardens in Honolulu. The monkey-puzzle or Chili pine[19] is also common about the city. The Monterey cypress[20] seems to thrive in the islands and is much esteemed as an ornamental tree.

A tree which is more common than any of the foregoing, and one which might be easily mistaken for a pine, is the Australian ironwood,[21] beefwood or she-oak. The fruit is cone-like in appearance and together with the needle-

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[7] *Caryota urens.* [8] *Washingtonia filifera.* [9] *Rhapis Cochinchinensis.* [10] *Rhapis humilis.*
[11] *Rhapis flabelliformis.* [12] *Arenga saccharifera.* [13] *Elæis guinensis.* [14] *Hyophorbe amaricaulis.*
[15] *Lantania glaucophylla.* [16] *Cycas revoluta.* [17] *Cycas circinalis.* [18] *Araucaria excelsa.*
[19] *Araucaria imbricata.* [20] *Cupressus macrocarpa.* [21] *Casuarina equisetifolia.*

PLATE 65. VIEW IN THE OLD GOVERNMENT NURSERY SHOWING A NUMBER OF RARE EXOTIC PLANTS.

In the foreground a bunch of Pampas grass (*Gynerium argenteum*); to the left a young date palm; in the background a fine Traveler's palm (*Ravenala Madagascariensis*).

like branchlets would seem to entitle it to claim relationship with the cedar, cypress or pine. Though the tree is widely distributed it was not known to the native Hawaiians before its introduction by the whites. The tree has its greatest use as wind-breaks. However, it has been extensively planted about the city and reminds the visitors from northern climes of the winter season as the wind whistles and soughs through its branches.

The Kukui.

Look where one will in the city he will find but little that really belongs to the native flora. The few species to be seen that pass as native trees are for the most part those brought here from Polynesia by the natives themselves. However, there are a few of these that are of common occurrence and especially striking in appearance. The kukui or candle-nut tree [22] is always identified by its conspicuous pale yellow-green, almost silvery foliage. It is one of the most beautiful and abundant trees of the group from sea level up to two thousand feet. In sheltered nooks and shady ravines the silvery-green foliage can be made out from far out at sea, and is usually proudly pointed out to the stranger from the deck of the steamer as one of the most beautiful and picturesque trees of Hawaii-nei. It is a luxuriant shade tree and is well worthy of a larger place in the parks, private grounds and streets of the city than it now occupies.

The wood is soft and white and is useless for building purposes; but the nuts, which are similar in shape and size to a black walnut, were made by the natives to serve in many useful ways. The shell of the nut is hard and black and capable of taking a very high polish. They were strung into leis and fashioned into other ornaments. The oily kernels were strung on splinters of bamboo to form torches, whence the name candle-nut. The acrid juice contained in the covering of the nut was the base for a black dye for tapa and also served as an ink in tatooing the skin. The nuts, roasted and mixed with salt, form a very pleasant side dish at native feasts. The oil was pressed from the kernels and burned in stone lamps of native manufacture. It also made a waterproof coating for tapa, and was occasionally used among the old-time Hawaiians to oil the body for various purposes, especially to render it slippery in evading their opponents in physical encounters. The gum which exudes from the bark also had several uses.

It is of interest in this place to note that all branches of the Polynesian race know the kukui by the same name. Though the kukui is generally dispersed over the islands, and forms a large part of the forest up to the upper edge of its range, it has but few enemies among the Hawaiian insects. This fact is taken to indicate its being of comparatively recent Hawaiian introduction, and suggests that there has not been sufficient time for it to attract serious insect pests.

The Breadfruit.

Another native importation of much value is the breadfruit,[23] or uhu, of the

[22] *Aleurites Molluccana.* [23] *Artocarpus incisa.*

PLATE 66. MISCELLANEOUS GROUP OF CULTIVATED PLANTS.

(For Description of Plate See Opposite Page.)

natives. It is planted singly about the gardens in the city and is quite commonly met with in groves of some size in the various valleys of the group. Wherever grown it adds materially to the beauty of landscape and in addition it has a great utility value. The young tree usually grows in the form of a perfect cone. The leaves are often two feet or more in length, dark, vigorous green in color and deeply lobed. The tree always has a thrifty look which it retains long after it has lost the charm of perfect form. The large green globular fruits are three to five inches in diameter and are especially esteemed by natives and Europeans as food. When very ripe the baked fruit has a flavor suggesting sweet potato. When cooked green the flavor is less pronounced and less pleasing. The tree attains a height of forty to sixty feet. The wood is a saffron color, very durable and not liable to split. Elsewhere it has been used to some extent in the manufacture of wheel hubs, but in Hawaii it is not used commercially. The Hawaiians used the leaves for polishing, the bark as a medicine, and the gum for capturing birds. Like the kukui, the breadfruit has accompanied the Polynesians on all their wanderings wherever the climate would allow it to live.

The tree is exceedingly difficult to propagate. As the Hawaiian variety rarely, if ever, produces fertile seed the plant has been distributed by root sprouts and by layerings. It is not as important here, however, as in Tahiti, where the fruit is made into a breadfruit poi.

Mango.

The mango [24] is a strikingly beautiful tree and is as much prized for its shade as for its delicious fruit. It forms one of the most stately trees to be seen in the city or about the islands. Its compact growth and its dense foliage of large, dark-green leaves serve to identify the tree, but the rich purple-red or red-brown young leaves, usually grouped on opposite sides of the tree at different seasons, make it especially conspicuous and worthy of remark.

Most of the trees bloom in January and the fruit ripens along in July and August. However, these dates vary greatly and are frequently reversed, so that there is hardly a day in the year when ripe, fresh fruits may not be found in the city. The bearing trees make but little growth owing to the heavy fruitage which bends low the sturdy branches. Often only one side of a tree will be in fruit at a time.

The fruit of the mango is of the most exquisite shape and color. It is about the size of a pear, ovoid, slightly flattened with the two sides developed unequally,

[24] *Mangifera Indica.*

Description of Plate.

1. A fine Algaroba tree [Kiawe] (*Prosopis juliflora*). 2. Leaves of the Sacred Banian (*Ficus religiosa*). 3. A Bougainvillea in full bloom. 4. A Rhapis Palm (*Rhapis Cochinchinensis*). 5. Bird's Nest Fern [Ekaha] (*Asplenium nidus*) from the native forest. 6. Flowers of *Clerodendron Thommsonæ*. 7. Fruit, flowers and leaves of the California Pepper (*Schinus Molle*). 8. Air-plant (*Bryophyllum calycium*). 9. A Cycas (*Cycas sp.*). 10. *Phylodendron* in an Algaroba tree; a Bottle Palm to the left, a Fan Palm to the right.

giving it a thick comma shape. When ripe the fruit is a rich yellow with apple-red cheek on the side turned toward the sun. But they vary in size, shape and color as much as apples do, for, like the apple, they seldom come true from the seed.

The tree is supposed to have originally come from India. It is the only one of thirty or more species belonging to the genus *Mangifera* that has any value. As many as five hundred varieties have been reported from India, and perhaps forty or fifty of the best sorts to be found are established in Honolulu. While usually grown from seed they may also be propagated by budding. This, unfortunately, is a somewhat difficult process involving much care and skill. Within the last few years the trees here have been affected with a blight not common elsewhere. It is due to a fungus disease that is thought to be aided in spreading by the blue-bottle flies and other insects carrying the spores from flower to flower. It will be noticed that the sooty mould, when severe, often gives the whole tree a blackened appearance.

Monkey-pod.

In almost every yard and square about the city, and indeed over the whole group, will be found one or more monkey-pod trees.[25] The better name for the tree is samang; although it is sometimes called the rain-tree, since it blossoms at the beginning of the rainy season in its native home in tropical America. It is an exotic, having long been introduced. It belongs to the great group of acacia-like plants, and has compound or multi-compound leaves. Like most of its relatives it has the habit of closing its leaves in sleep at night. After sundown it presents a wilted appearance and does much toward changing the aspect of the whole city after nightfall. Trees of this species that are several feet in diameter at the girth and spreading shade over a space 150 feet across, are to be commonly seen about the islands. It is a permanent shade tree, and aside from the litter of the discarded leaves and pods and a slightly ragged appearance during the winter season it is highly desirable as an ornamental tree. As a tree to be planted along the sidewalks it is hardly to be recommended, as it grows at such a furious rate that it is liable to lift the walk and injure the curbing. It is therefore a tree better suited to ample lawns, open spaces and parks.

The Algaroba.

Of all the introduced trees the algaroba[26] is the favorite. It is a mesquite, perhaps of the southwestern United States and Mexico, and has been greatly improved and modified by the change of environment. The original tree in Hawaii grew from a seed planted in 1837 on Fort street, near Beretania, by Father Batchelot, founder of the Roman Catholic mission. It is thought that the seed was brought from Mexico, though this point is far from being settled by the historians of the islands. The tree is still in a thrifty condition and is the pro-

[25] *Pithecolobium Samang.* [26] *Prosopis juliflora.*

genitor of more than 60,000 acres of forest distributed over the entire group. At first it grew only at the lower levels, but, little by little, succeeding generations have crept higher and higher until now they thrive from the sandy sea beach to 1,500 feet elevation. The lee coasts of Oahu, Molokai, and parts of Hawaii have been changed from deserts to forests by the algaroba alone. Curiously enough, the land which it has taken possession of is usually arid or stony, or so steep that it was considered generally worthless. If left alone they shade the ground with a dense growth and attain a height of fifty to sixty feet. When trimmed and thinned, as they are in the city, their delightful shade moderates the heat of the tropic sun, allowing the growth of the lawn grass beneath, and in dry seasons protecting it from the direct rays of the sun. Their slender, brittle branches are often too much in evidence to be asthetic in themselves, but nevertheless they have a weird picturesqueness of their own. The trunk at first seems uncouth, but there is a grace and poise to the slender vine-like branches and feathery leaflets as they toss to and fro in the trade wind, that over-balances the ruggedness of the gnarled and twisted trunk.

In addition to its asthetic qualities the algaroba is one of the most useful of trees. Besides yielding an enormous amount of wood of splendid quality, they are valuable for the pods that are produced with great regularity after the tree is three years old. The pods ripen gradually during the summer months, and, next to the grasses, form the most important stock food. They are eaten by horses, cattle and hogs with great relish. The hard, horny seeds which are embedded in a sweet pulp are not digested by the stock, and hence are in prime condition for growing and are scattered broadcast in this way.

The algaroba is also our most important honey-producing plant. Bees are exceedingly fond of the nectar of the flowers and the sugar of the beans. Many apiaries in algaroba groves produce honey of attractive appearance and superior flavor.

The tree exudes two different kinds of gum. The most valuable collects in clear, amber-colored, tear-like masses on the bark. It resembles the gum arabic of commerce. As it contains no tannin and desolves readily in water the gum has elsewhere been used in laundries and to some extent in the manufacture of gum-drops. In Mexico it is also valued for certain medical properties. In Hawaii it has never been collected or used, though large quantities of the gum could be secured.

CHAPTER XVIII.

A RAMBLE IN A HONOLULU GARDEN: PART TWO.

The Poinciana.

Turning to the purely ornamental trees, first place is usually given to the scarlet-flowered royal Poinciana,[1] or to one of the closely allied species or varie-

[1] *Poinciana regia.*

ties. The common species grown here, known as the "flame tree" or "flamboyant tree," has been so well named as to scarcely require further description. Though it is a fairly rapid grower it is not a large tree as a rule. The smooth trunk is expanded at the base in a curious way, forming buttresses that correspond with the principal roots. This peculiarity in connection with its rich-green foliage arranged in horizontal spreading layers of fine pinnate leaves, makes it a tree so dainty as to attract attention at all seasons. But when it bursts into full flower it is one solid mass of crimson, the admiration of all, and without doubt it is one of the most striking of tropical trees. Although it sheds its leaves at certain seasons it is at such times almost as remarkable for its large pods as for the blossoms which preceded them. The generic term, which is the one commonly used as the name of this species, was given in honor of Governor-General Poinci, who wrote on the natural history of the West Indies during the middle of the seventeenth century. The species and varieties common in warm countries are found here.

Pride of the Barbadoes and the Golden Shower.

The pride of the Barbadoes,[2] with orange-colored blossoms and a second variety with yellow flowers, are quite common, the latter being known as the yellow poinciana. But more conspicuous through the summer months is the golden shower,[3] or after the pods have set on it, the "pudding-stick" tree. The foliage is quite scant, consisting of large pinnate leaves. The flowers appear in pendant panicles and for several months there is a succession of pure primrose-yellow, fragrant blossoms that justify the popular common name of the tree. Another species is the purging Cassia[4] or horse Cassia, with pink and white flowers and leaves that somewhat resemble the locust. It is most conspicuous when bearing the large club-like pods eighteen to twenty inches long and an inch or more in diameter. Another species known locally as the "pink shower" resembles the latter in many ways, but has the pods divided off with transverse diaphragms separating the seeds which are embedded in pulp. In this species[5] each seed is enclosed in a tiny pillbox-shaped case, the seeds lying collectively in the pod like so many coins rolled together in a case. The flowers grow in clusters closely resembling those of large, rich-colored crabapple blossoms and surround the bough of the previous year's growth. The tree remains in full blossom ten or twelve weeks and is a delight to all beholders. But of this large genus there are numerous species represented in the introduced flora of the islands, many of them producing handsome trees and shrubs.

Pride of India.

The pride of India,[6] also a second and smaller species from Jamaica,[7] both with delicate lilac-colored flowers, are often called the "umbrella tree." The flowers are followed by a crop of yellowish berries which are eaten and dis-

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[2] *Cæsalpinia pulcherrima.* [3] *Cassia fistula.* [4] *Cassia nodosa.* [5] *Cassia grandis.*
[6] *Melia Azedarach.* [7] *Melia sempervirens.*

tributed by the mynah birds. The larger species without doubt came originally from India, but has been extensively planted in warm climates everywhere.

The tamarind,[8] a name which, by the way, is derived from the Arabic meaning "Indian date," is an exceptionally beautiful and useful tropical tree. It attains a great height and its delicate acacia-like foliage crowded together so as to produce a dense head makes it a shade tree that is considered by all travelers to be one of the noblest in the tropics. It is probably a native of India or Africa, but has been generally introduced in tropical countries. The pods, numerous and from three to six inches long, contain an acid pulp that in the islands is made the base of a cooling drink of much the same character as that made from lemons or limes. Occasionally the pulp is also used in making a delicious tamarind butter, but as a general rule they are allowed to fall to the ground or to be carried off by roving children. The wood is greatly esteemed in the manufacture of furniture. It is yellowish-white, sometimes with varicolored sap streaks, and is very hard and close-grained.

The Banian.

The Banian (or Banyan) tree, a name derived from the fact that it furnished shelter for the open markets of the banians, or Hindu merchants, and therefore literally a "market place," is a common tree in Honolulu. The family to which it belongs is well represented in the gardens and parks of the city, there being at least a dozen or more of the large arboreal species that can be easily recognized, usually, though not always, by the pendant aërial roots. The Banians all belong to the great order[9] to which the common fig[10]; the Indian rubber plant,[11] the Bengal banian tree,[12] and the creeping fig[13] on our garden walls, as well as some six hundred other similar species scattered throughout the tropics, are referred. The most ornamental plant, perhaps, is the India rubber plant. But the great spread of the typical banian tree, which sends down some of its branches or aërial roots that in time take root in the soil, is one of the largest and most thrifty-looking trees growing in Hawaii. Many of the related species have the same or similar methods of reproduction.

Pepper Tree.

Among other important shade trees in the islands must be mentioned the pepper tree[14] that grows so extensively throughout California. It is easily recognized by its graceful, swaying branches and red berry-like clusters of fruits about the size of peppercorns, from which resemblance it derives its popular though misleading California name.

The kamani,[15] or tropical almond, often planted for the shade afforded by its broad, horizontal branches and large, broad leaves, is an introduced species coming originally from Asia. Before the leaves fall they take on the brilliant autumn colors common in cold climates, and thus add much to their picturesque beauty. The tree is also known as the Demerara almond, on account of the

[8] *Tamarindus Indica.* [9] *Urticaceæ.* [10] *Ficus Carica.* [11] *Ficus elastica.* [12] *Ficus Benghalensis.*
[13] *Ficus pumila.* [14] *Schinus Molle.* [15] *Terminalia catappa.*

PLATE 67. VARIOUS VIEWS IN HONOLULU GARDENS.

(For Description of Plate See Opposite Page.)

edible almond-like, filbert-flavored nut they produce. The nuts may be eaten either raw or roasted.

This tree should not be confused with the native kamani [16] which has beautiful glossy, oblong or ovate leaves and globe-shaped nuts an inch or more in diameter. This species is a splendid ornamental tree that is believed to be an ancient Hawaiian introduction, as it occurs throughout Polynesia and southern Asia.

The Wattle.

The black wattle [17] and the silver wattle [18] have been cultivated in Hawaii for nearly half a century, and these or their numerous relatives are common in the city and constitute the chief trees planted in the Tantalus forest. Likewise the Australian oak or silk-oak,[19] is common in parks and gardens and is easily recognized by its fern-like leaves and sweet-scented golden-yellow trusses of flowers.

Of the bananas and citrus fruits, and fruiting vines, that have some commercial value and are grown both for their fruit and foliage, we will say nothing here, deferring so engaging a subject for another chapter. Next to the trees in their striking ornamental effect, however, are the numerous species of vines and vine-like plants everywhere about the city. The property holder in Honolulu feels that his fence, his house, and his out-buildings are doing full duty only when loaded with a profusion of luxuriantly flowering vines, and there are perfect tangles of vines and blossoms about many homes.

Bougainvilleas.

The most conspicuous of all in this class are the Bougainvilleas. Magenta, scarlet-red and brick-red are among the common forms, and as to abundance they occur in the order mentioned. Of the magenta colored species [20] there are two common varieties, one of which is an ever-bloomer. Throughout the year this species is one continuous mass of purple, and is one of the most striking of the introduced plants. The salmon, brick-red, orange and scarlet varieties are to most people more pleasing than the brilliant magenta species; but when a blaze of color is required, the Bougainvillea of any shade will never be a disappointment. The curious thing about them is that it is not the blossoms after all that are so remarkable. An examination shows that it is only the bracts that enclose the inconspicuous flowers that are so highly colored. All told there are

[16] *Calophyllum Inophyllum.* [17] *Acacia decurrens.* [18] *Acacia dealbata.* [19] *Grevillea robusta.*
[20] *Bougainvillea spectabilis.*

Description of Plate.

1. Japanese flower peddler. 2. Night-blooming Cereus (*Cereus triangularis*) on Oahu College wall. 3. Washington Palm (*Washingtonia filifera*); to the left a Royal Palm (*Oreodoxa regia*); to the right, a Date Palm (*Phoenix dactylifera*). 4. *Zamia sp.* 5. A Banian tree (*Ficus Indica*), showing the curious aërial roots. 6. Wine Palm in fruit and flower. 7. The Monstera (*Monstera deliciosa*). 8. A Mangosteen (*Garcinia Morella*) or Gamboge tree.

perhaps a half-dozen or more of these South American shrubs from which several varieties have been propagated. The name was given in honor of Bougainville, an early French navigator.

ALLAMANDA.

The Allamanda, with two or three species, one of which [21] is a conspicuous vine especially common about verandas, is easily recognized by its thick, green leaves and large, fragrant yellow flowers that are always blooming. Another favorite is the trumpet-creeper or fire-cracker vine.[22] Its orange-red flowers are the color of living flame of varying shades and tints. When in blossom (and it blossoms for weeks at a time), the green of its foliage is often completely hidden from view, and the porch, barn or out-building over which it runs is a magnificent show of flowers.

OTHER VINES AND SHRUBS.

A favorite especially suited to stone walls and to some extent as a climber in trees, is the Bignonia or bird-claw vine.[23] The Bishop Museum is literally overrun with this rich, glossy-green climber, and at certain seasons the beautiful yellow blossoms transform its otherwise uninteresting exterior into a palace of gold. The masses of this flowering vine as they hang pendant from the tallest trees about the city produce a vision of airy, golden loveliness that lingers long in the mind's eye. More prized perhaps than any of the foregoing, but unfortunately less common, is the Stephanotis,[24] known as "Kaiulani's flower." Its fragrant white blossoms at certain seasons transform the trellises of the city into veritable banks of snow. With the Stephanotis will often be seen a fragrant climber, known as the wax-plant,[25] so named on account of the thick, waxy leaves and wax-like star-shaped flowers.

Here and there in old gardens one sees various species of Convolvulus, giving a touch of the familiar morning-glory blue to the scene, or, with as much ease a dash of yellow [26] from India and the Orient. The pretty climbing Mexican creeper or mountain rose,[27] "Rosa de la Montana de Mexico," with its delicate sprays of pink blossoms, and the more obscure though wonderfully fragrant Chinese violet [28] with greenish yellow blossoms, are both always in evidence.

Several species of jasmine are common. The beautiful climbing snow-white [29] is a favorite, as is the perpetually blooming Arabian jasmine,[30] with handsome white flowers that turn purple as they die. The beautiful purple wreath [31] is one of the most striking of the rarer climbers; the five-pointed deep-lilac flowers hang in graceful racemes and come into full bloom in April and May, lasting several weeks.

More conspicuous and tropical than any of the foregoing are the several species of arboreal plants with large foliage leaves, the number of which growing in Honolulu is too great to receive more than passing notice here. The

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[21] *Allamanda cathartica.* [22] *Bignonia venusta.* [23] *Bignonia ungis-cati.* [24] *Stephanotis floribunda.*
[25] *Hoya carnosa.* [26] *Ipoemoea chryseides.* [27] *Antigonon leptopus.* [28] Native name 'Pakalani.'
[29] *Jasminum grandiflorum.* [30] *Jasminum Sambac.* [31] *Petrea volubilis.*

South American group of tree-loving *Philodendrons* is represented by perhaps a dozen species that are among the more common climbing plants. They are usually characterized by broad coriaceous, though often with divided, leaves and are to be seen hugging palms, climbing trees and running over stone walls everywhere about the city. The *Monstera delicioca,* like the foregoing, is a tree-loving plant and is easily recognized by the enormous dark-green leaves that are occasionally two feet in length and pierced by curious, large elliptical holes. The flowers are small and betray the plant's relationship to the order *Araceæ,* to which great group the taro and the calla lily belong, by having the boat-shaped, creamy-colored spathe. The succulent fruit of coherent berries requires many months to ripen. But it eventually becomes a fruit a foot long by two inches in diameter, resembling an ear of corn in shape and having a very delicate tang suggesting both the pineapple and banana in flavor.

The city abounds in ornamental shrubs. What it lacks in annual and perennial flowering plants is compensated for by the gorgeous, highly-colored and varied leaves of this class of ornamental plants.

The Christmas flower, or poinsettia,[32] is recognized by the stranger in the islands from temperate climates as a familiar hot-house friend. But instead of being a scraggy plant growing in a tub, it grows in Hawaii in the open and attains a height of fifteen to twenty feet. At Christmas time it is most conspicuous, lighting up the city with the splendid scarlet-red of the flowers, though the so-called flowers are in reality a cluster of large leaf-like bracts that surround the small insignificant blossoms. A white variety is also occasionally seen about the city.

The poinsettia belongs to the great tribe of euphorbias and has a white milk-like juice. The genus was named as long ago as 1828 for the Hon. J. R. Poinsett, an American minister to Mexico, who discovered the common species now in cultivation, growing wild in that country.

Of recent years the beautiful Ixora has found much favor as a Christmas flower owing to its large, showy clusters of bright-red blossoms and large glossy-green leaves. The plants, however, do not confine their flowers to the holiday season but generally extend their Christmas cheer throughout the year. The species most common in Honolulu is a member of the typical genus in the tribe *Ixoreæ* which belongs to the larger order *Rubiaceæ,* to which the coffee plant belongs. The generic name *Ixora* is given as the name of a Malabar deity to whom the flowers are offered in their native country. A number of the hundred or more species belonging to the typical genus are occasionally met with in hot-house collections in Europe and America, but in the congenial climate of Hawaii they thrive with but little care, forming one of our most attractive and conspicuous garden shrubs.

The crotons of the floriculturist, so extensively grown as foliage plants in Hawaii, are not crotons at all but Codiaeums, and like the foregoing, belong to the great order *Euphorbiaceæ.* The word Codiaeum is of Malayan origin, and it is

[32] *Euphorbia pulcherrima.*

PLATE 68. BLOSSOMS FROM A HONOLULU GARDEN.

1. Purple wreath (*Petrea volubilis*). 2. Madagascar Periwinkle (*Vinca rosea*). 3. Fire-cracker vine (*Bignonia venusta*). 4. Spanish Jasmine (*Jassimum grandiflorium*). 5. Bird-claw vine (*Bignonia unguis-cati*). 6. Senna (*Cassia sp.*). 7. Thumbergia (*Thumbergia laurifolia*). 8. Beaumontia (*Beaumontia grandiflora*). 9. Mexican Creeper or Mountain Rose (*Antigonon leptopus*).

from there the single species with three well-marked varieties have been distributed all over the world to be developed into more than a hundred cultivated forms and sub-varieties. While most of the forms have been given names, the practice among botanists is to regard them all as belonging to one species.[33] A majority of the best known forms may be found growing in Honolulu gardens.

These beautiful plants, with their many forms of odd and handsome foliage of the most brilliant coloring, are to be seen in profusion everywhere. The colors range from almost pure white to light and deep yellow, orange-pink, red-crimson, and all these joined in the most remarkable combinations. In some cases one color predominates, in others every possible combination is represented. But a close study of the form of the leaves will demonstrate that three principal types exist, namely, those with ovate, short-stalked leaves, those with narrow and spatulate leaves, and those with narrow and often cork-screw twisted leaves. Planted in clumps and masses the effect produced by the combination of their rich colors is charming. They are often used to advantage as hedges and are made in one way or another to give color to almost every lawn.

The garden varieties of Coleus are also a legion, and many of them or their near generic relatives thrive in the city and occasionally escape, as on Hawaii, into the wooded stretches along the roads and lanes. A very deep-red, large-leafed foliage plant of this family is in general favor. It is planted in rows to form hedges about gardens and is wonderfully varigated in foliage.

Hedge Plants.

The hedge plant that is most conspicuous and, happily, the most common in Hawaii is the Hibiscus. Of this splendid shrub about six forms and innumerable varieties are in general cultivation. Of the common varieties, miles and miles of hedges have been made. These are among the first objects to attract the attention of tourists and visitors, and one never tires of the display of blossoms of all sizes and colors that line the street. There are at least four native species, two or more of which have been cultivated to some extent by Hibiscus enthusiasts. Much has been done here and elsewhere along the line of producing new varieties by cross-breeding, so that every color from white, yellow, salmon to deep red, in double and single blossoms, are abundant. It is to be hoped that this splendid shrub may become so popular as to be regularly adopted as the "City Flower" of Honolulu. As the hedges of scarlet and pink Hibiscus are ever a delight to the eye a keen rivalry may well develop among householders in the production of rare forms, since new varieties are easily produced by cross pollenization.

Ki.

A plant that is common in the mountains and is often planted in hedges is the ki[34] plant, the Dracæna, or more properly the Cordyline of botanists. There are several cultivated varieties, especially one with wine-red leaves that are com-

[33] *Codiæmus variegatum.* [34] *Cordyline terminalis.*

mon in Honolulu gardens. The natives find many uses for it that must be mentioned elsewhere. Its leaves are articles of daily use, however, especially as a wrapping for fresh fish in the markets.

Still another shrub that is a favorite for hedges in the city is the beautifully variegated *Phyllanthus rosco-pictus.* The leaves are small, alternate, and entire in two rows on small branchlets, so that they appear like pinnate leaves. They vary in color, being variously mottled with pink and red as well as with white and green.

Most of Hawaii's visitors who come from northern climes for their first visit to the tropics are greatly surprised to find the Oleander,[35] variously called rose-bay, rose-laurel or South Sea rose, growing in beautiful ever-blooming hedges ten to twenty feet in height. This old-fashioned evergreen shrub, so common as a hot-house pant, flourishes here with but little care and blossoms in various shades of pink, white and cream color. It is not generally known that all parts of the Oleander are poisonous, and that there are authentic records of people who have died from eating the flowers; death has also occurred from using its wood as skewers in cooking meat.

A beautiful tree frequenty seen in gardens about the islands is locally known as the "bestill-tree," owing to the fact that its large, slender, daintily poised, shining green leaves are set in motion by the slightest breeze. It is also called the yellow Oleander, on account of its golden, funnel-shaped flowers that are further characterized by having the edge of the corolla made up of a series of over-lapping lobes. The flowers and the foliage suggest the typical Oleander—to which it is distantly related—and makes the name not inappropriate even though it is not a true *Nerium.* This common species *(Thevetia neriifolia)* is elsewhere known as the quashy-quasher, and is widely distributed in the tropics, particularly in the West Indies and tropical America. The wood is hard and even-grained, and its seeds yield the fixed oil called exile-oil. The genus belongs to the great order *Apocynaceæ,* which includes in its numerous tribes such well-known and widely-differing ornamental plants as the Vinca, Oleander, Allamanda, and the Plumieria.

Pandanus.

Several species of Pandanus or screw-pine are found growing, in old gardens, some forms attaining great size. They are remarkable for their stilt-like aërial roots, and the perfect spiral arrangement of their long sword-like leaves, which are held aloft on a few scarred, naked branches. The aërial roots gradually lift the trunk out of the ground, but at the same time anchor it firmly in all directions. Two species are common, one of which is a variegated form. There is not space here to go deeply into the question of varieties, for there are as many as fifty species known and many of them are in cultivation in Honolulu gardens.

The splendid specimens of Hercules' club, or angelica tree,[36] commonly

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[35] *Nerium Oleander.* [36] *Aralia spinosa.*

called Aralia, are often among the more showy plants about houses and on lawns. Another species[37] has white margins to all the leaves and is much esteemed and used as a quick-growing hedge. The candied leaf-stalks of angelica are not an uncommon confection.

The Plumeria[38] is a favorite, especially with the natives, and few of their gardens are without one or more of these curious plants. From the white-and-yellow flowers they are accustomed to make leis (wreaths) that rival in sweetness the jasmine or the tuberose. Though they may be unsightly in appearance for a month or two, when the leaves drop from their thick, club-like stems, they make ample atonement for this defect during the rest of the year when they are bedecked with a profusion of rich-colored, star-shaped, sweet-scented blossoms. The genus was named for a celebrated French botanist, Charles Plumier, and includes about forty species, three or four of which are grown in Hawaii.

FERNS.

Although ferns abound in every garden, there are but few that belong to the native flora. Perhaps the curious bird's-nest fern[39] or ekaha, is the most conspicuous of this class. It stands out boldly against the background, formed by the trunk of the tree in the fork of which it is established and is often five or six feet in diameter aross the curious whirl of paddle-shaped leaves. It grows naturally in the mountains, but stands transplanting in tubs and rockeries in the city. The tree ferns which abound in the native forests are seldom seen in the city. They do not thrive in the drier climate of the lower zone. This is unfortunate as nothing in the native flora could be more ornamental. Owing to the difficulties encountered in growing native mountain ferns the town gardener has come to depend to a large extent on the hardy fish-tail or Boston fern[40] and everywhere, in the ground, in pots and hanging baskets this species thrives. The beautiful, graceful, dark-green, always fresh looking, maile-scented Staghorn fern (*Gleichenia longissima*), a favorite for hanging baskets or rockeries, is a vigorous grower in the low altitudes, and prevents the fishtail from having an apparent monopoly of this style of ornamentation. But in hot-houses, where the amount of moisture and sunlight are more easily regulated, a profusion of rare and beautifully delicate ferns are grown that are the source of just pride among growers and furnish the basis for much rivalry among the inhabitants of Honolulu. Some of the larger collections have scores of species represented, among them some of the most delicate, as well as the largest and most showy forms known.

Coming to the garden flowers, the visitor is usually doomed to disappointment. Although almost any of the flowers in general cultivation elsewhere will grow with little care and many of them thrive here, it is the exception to find a yard in which any attempt is made to have a flower-bed of annuals, much less an old-fashioned flower garden. In place of flowering plants bordering the driveways, foliage plants and ferns are quite commonly substituted. Occasionally,

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[37] *Aralia Guilfoylei.* [38] *Plumeria acutifolia.* [39] *Asplenium nidus.* [40] *Nephrolepis exaltata.*

however, flowers are planted, but usually such hardy bloomers as white and pink Vinca [41] will have their place about the base of a palm tree or by the garden wall, and likewise the beautiful blue phlox-like leadwort [42] will be seen, but as a rule the flowers that one sees are such as require little care and are perennials. As there is abundant color in the flowering trees and shrubs one does not miss the old-fashioned flowers as much as otherwise would be the case.

The old-fashioned four o'clock [43] is a familiar flower so long established in Hawaii, that, in favorable situations, it has escaped and grows by the roadside. They are handsome, branching herbs with opposite leaves, the lower petiolate, the upper sessile, and with quite large, often fragrant, flowers which are white, scarlet, or variegated. There are perhaps a dozen other species that are native to the warmer parts of America, a few of which are occasionally cultivated, but the common four-o'clock, or marvel of Peru, is the one usually seen. It derives its name from the fact that the flowers open daily in the late afternoon.

Occasionally the curious sprouting-leaf plant, or "air" plant,[44] will be seen in some neglected corner, and will be identified as a begonia-like plant that may be propagated by leaf cuttings. In fact, if one of the thick, fleshy leaves is pinned to the wall, little plants will spring up from the notches on the edge of the leaf.

Night-blooming Cereus.

It would not do to draw this long chapter to a close without mention of the wonderful blooms of the night-blooming Cereus.[45] Likely as not fragments have been carelessly piled on the stone fence at the bottom of the garden where they have grown unnoticed until they have transformed an unsightly fence into the semblance of a sprawling evergreen hedge. At intervals of not more than a few weeks, especially during the summer, it clothes its ungainly, fleshy, triangular stems with giant creamy-white, lily-like blossoms a foot or more in diameter. Few there are who have visited Honolulu and not been delighted by the famous cactus hedge at Punahou Academy. On the wall about the campus is a continuous stretch of Cereus, five or six hundred yards in length, on which thousands of these great flowers may be seen in blossom each year. They open soon after the sun goes down and remain in full bloom during the night. But by nine o'clock of the following day the glory of the night before will have departed, although the following night belated blossoms will somewhat restore it. Fortunate, indeed, is the visitor whose 'ramble in a Honolulu garden' has been so timed that he may be present at the "Cereus season," since the occasion is without doubt one of the most remarkable and wonderful of the city's many floral exhibitions. The night-blooming Cereus is a wonderful climber; it has clambered high into many large algaroba trees in Honolulu, its magnificent blossoms tantalizing beholders by being out of reach.

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[41] *Vinca rosea.* [42] *Plumbago Capensis.* [43] *Mirabilis Jalapa.* [44] *Bryophyllum calycinum.*
[45] *Cereus triangularis.*

CHAPTER XIX.

TROPICAL FRUITS IN HAWAII.

Until recently the brains and energy of the people in Hawaii have been so centered on developing the more profitable field crops, that but little systematic effort has been put forth towards the introduction and cultivation of edible fruits. Nevertheless many delicious fruits are found growing in the islands in both a wild and cultivated state. In much the same way that we compare Honolulu to a botanical garden, by reason of the number and variety of its ornamental plants, we may compare Hawaii to a great unkempt experimental orchard.

Native and Introduced Fruits.

Many rare, curious and toothsome fruits have been brought to Hawaii from the ends of the earth in times past by fruit lovers. But, unfortunately, they have too often been planted out among ornamental plants, in out-of-the-way places or left in neglected corners to shift for themselves. With few exceptions such plantings have not materially advanced the cause of fruit-growing more than to help demonstrate that a long list of worthy fruits will grow in Hawaii almost without attention.

Many native-grown species of our most common fruits are seldom, if ever, seen in the markets of Honolulu, while the great majority of the list of island species are to be seen only in the private grounds of the older residents. Although it is true that most of the varieties as yet have a greater ornamental than commercial value, a few, as the pineapple and the banana, are extensively cultivated. Their production has come to be important industries. It is to a brief review of some of the more interesting and important of the island fruits, both native and introduced, that this chapter is devoted.

Botanists tell us that the islands at the time of their settlement by the aborigines had few native indigenous fruits. The Chilian strawberry[1] has long flourished on the high mountains of Hawaii and East Maui at an elevation of from four to six thousand feet. The natives have always held this small though delicious berry in high esteem under the name ohelo papa. It seldom reaches the market, but from May to September it is abundant; on Hawaii it is one of the principal articles of food for the Hawaiian goose. There are several cultivated species of better quality that find their way to market. Strawberries do not thrive well at sea-level, but prefer the higher and cooler regions. As a result they are grown in beds in Nuuanu Valley, at Wahiawa and elsewhere, where conditions are favorable. By changing the elevation, moisture and soil conditions, an extended period of bearing is secured. As a matter of fact, if they were more skilfully handled, fresh strawberries could be grown for the market every day in the year. As it is there is not more than a month or so when fresh fruit cannot be secured.

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[1] *Fragaria Chilensis.*

Native Raspberries.

There are at least three, and probably more species of the native raspberry, or akala. They prefer the high altitudes and have been found growing on all of the high islands with the exception of Oahu. In the deep woods on Molokai, at the head of Pelekunu Valley, I have found the spineless Hawaiian raspberry [2] growing under ideal wild conditions, as a perennial, attaining a height of twelve to fifteen feet, with stems three or more inches in diameter at the ground. While the fruit is neither abundant nor of especially good quality, the few berries that it produces are of large size and attractive appearance. The species is worthy of propagation by horticulturists, on account of the important characteristics possessed by it that might be developed through cross-fertilization.

In the mountains of Hawaii and Maui is found a low-spreading, prostrate shrub with long, stiff, trailing branches that bear round, black fruit about a half inch in diameter known to the natives as kukui neenee.[3] The fruit is not pleasant to the taste, but the wild Hawaiian goose feeds voraciously upon it. They are common in the open country about the Volcano House.

The Ohelo.

Of more importance and general interest than the foregoing are the beautiful and delicious ohelo berries [4] found especially abundant about Kilauea. They belong in the same genus with the familiar bog-cranberry of commerce. The berry is like the cranberry in size, shape and color. It is slightly astringent, but not enough to render it unpleasant to the taste, when eaten out of the hand. It also makes excellent pies and preserves, and being a very prolific bearer is worthy of attention by those interested in the production of new fruits. The berries vary greatly in color from almost white, through various shades of yellow and red to almost purple, and are covered with a waxy bloom. They grow crowded together along the branching stems of the low erect shrub, which attains a height of from one to two feet. The bush grows more or less in patches, often covering considerable areas. In former times it was used as a propitiatory offering to the goddess Pele, and a century ago no Hawaiian would approach her abode without first making a suitable offering of these berries to the far-famed goddess of the volcano. The Hawaiian islands have two distinct species and several recognized varieties, though the berries of the taller species, fairly common in the highest mountains of the different islands of the group, are seldom eaten.

Mountain Apples.

An important native fruit tree, or at least one that must be considered as of early native introduction, is the mountain apple, or ohia ai.[5] The tree attains a height of from twenty-five to fifty feet, and usually forms a clump or grove

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[2] *Rubus Macræi.* [3] *Coprosoma ernodeoides.* [4] *Vaccinium reticulatum.*
[5] *Jambosa = (Eugenia) Malaccensis.*

along the streams. In the forest they are easily recognized by their dark-green leaves and waxy-red or deep-crimson fruits, which are as large as apples and are borne twice a year in great profusion. In the market the fruit is of such attractive appearance that the watery, insipid flavor comes at first as a disappointment; however, the curious cooling property of the fruit compensates for what it lacks in flavor. It bruises easily in handling and is but little used, except occasionally in making sweet pickles. The tree occurs on all the larger islands of the Pacific and is highly esteemed by the natives for its fruit. The fragrant flowers were formally the favorite haunts of several of the native birds, which were caught in the branches by the use of bird lime. While the tree grows here and there in the city of Honolulu, it is by no means common, and must be seen in its native habitat to be appreciated at its full worth as a forest tree.

Poha.

The poha, cape gooseberry, or ground cherry,[6] is a spreading shrub belonging to the great tomato family. It bears yellow berries in a bladder-like calyx, and grows quite common on mountain slopes throughout the group, especially on Hawaii and Maui. The fruit is edible, has a pleasant flavor and when cooked makes an excellent jam. In this form it has established a place for itself in Hawaii at the head of the list of preserves. It is only occasionally seen in the market in the raw state, and as it is mostly gathered from the wild plants, it is usually high in price. The plant is said to be a native of Brazil, but has long been naturalized in Hawaii. As it is only one of some thirty or more known species, it is quite possible that it would be worth while to introduce other species for cultivation.

Bananas.

The banana is a conspicuous and valuable plant everywhere in the tropics. The striking bunches of fruit, and its broad, bright-green leaves occupy a prominent place in the ornamental foliage about almost every home in Hawaii. The banana is important among the commercial fruit-bearing plants of the islands. If we accept the broadest use of the term, the word banana includes all of the species and innumerable varieties of the genus *Musa*. This genus, which is supposed to have been named for Antonius Musa, a physician to Augustus the Great, belongs to the order *Scitaminaceæ*, to which also belong several genera, including many well-known plants found growing in Honolulu gardens—such conspicuous ornamental plants as the traveler's palm or traveler's tree,[7] the Canna and ginger[8] being among them. The original home of the banana is thought to have been southern Asia. Doubtless it has been long ages under cultivation, and in very early times found its way into Polynesia. For this reason it is thought that the wild, or native banana, or maia, found growing everywhere in the mountain valleys, even in the most remote districts of the

[6] *Physalis Peruviana.* [7] *Ravenala Madagascariensis.* [8] *Zingiber.*

PLATE 69. WILD AND CULTIVATED FRUITS.

1. Breadfruit [Ulu] (*Artocarpus incisa*). 2. Chinese Banana [Maia] (*Musa Cavendishii*). 3. Avocado or Alligator Pear (*Persea gratissima*). 4. Pineapple (*Ananas sativus*). 5. Thimble Berry (*Rubus Jamaicensis*). 6. Mango (*Mangifera Indica*). 7. Ohelo Berry (*Vaccinum reticulatum*). 8. Purple Water-lemon [Lilikoi] (*Passiflora edulis*).

group, are all of very early Hawaiian introduction from the islands to the south of the Equator. The natives know as many as twenty-five and perhaps fifty varieties of so-called wild bananas, having a name for each, but as the same fruit is known by different names on different islands, many names disappear as synonyms. It has been found that three main groups or types can be recognized. But the native nomenclature will doubtless withstand the attacks that may be made upon it by the systematic botanist and horticulturist, and as a consequence, the more important and striking forms will long continue to be recognized, in the markets at least, by their native names.

While the original plants were doubtless set out well up in the mountain valleys, in sheltered, moist, well-drained places, by the native planters, they are now distributed along the streams. In certain sections peculiar forms are common, and it is not improbable that new varieties have been originated in the islands by the natives through intelligent selection, or by isolation, or from other causes. The koae, for example, is a striped variety, having the fruit and leaves variegated with pale and dark green, that is said by some to have originated in Kona, Hawaii, and to have been brought from there to Honolulu for ornamental purposes. The oa is striped, reddish and green, and like the variety just mentioned is also said to have originated in Kona. Other interesting varieties of possible local origin are the poni, or black-trunked banana, the rose, and the sweet-scented varieties.

Among Europeans the nomenclature of the banana is in an uncertain state. The same varieties have different names in each country where grown; even the class terms, plantain and banana, are used with varying meanings. In some localities the plantain is understood to mean almost all the edible species, while in other localities banana has an equally wide and uncertain application. It is urged that the better usage is to reserve the term plantain for the varieties that can only be eaten after they have been cooked. Since it is the custom to recognize two kinds of bananas, namely, cooking and eating, the two terms, used so far as possible as above, would be generally useful.

In addition to the many excellent native varieties that are to be had in the local market, there are a number of introduced species and varieties which, though they stand high, are of but little commercial importance, as they will not stand packing and shipping. This class includes some of our best table bananas; the Brazilian, the apple, the largo, the kusaie, and a long list of other less common ones should be mentioned as among the more important. Of the native varieties the iholena and lele are considered as the choicest varieties for both cooking and eating.

The most important commercial varieties are the Chinese or Cavendish,[9] the Jamaica, Martinique or Bluefield, and the red Spanish or Jamaica red. The latter is sold in the fruit stalls as a fancy variety. The Bluefield, which takes its name from the principal port from which the variety is shipped into the United States, was introduced into Hawaii in 1903 and has been fast winning

[9] *Musa Cavendishii.*

favor among the more intelligent growers, as it sells in the market at about one-third more per bunch than does the common Chinese variety. Its fruit has a tough, slow-ripening, golden-yellow skin, and the hands, or clusters, grow in large, very compactly-arranged bunches.

The Chinese variety was introduced into the islands from Tahiti about 1855, and has long been the leading commercial banana. It is characterized by its low growth and large bunches of yellow fruit of fine flavor and good keeping qualities. Only a single bunch is produced by a plant. The fruit ripens at all seasons, requiring, in low levels, ten to twelve months for the bunch to mature; in higher elevations, twelve to eighteen months.

It has been found that an acre of good ground under favorable conditions, well watered and tilled, will produce in a year 1,200 bunches of bananas weighing sixty pounds each. While dried banana and "banana flour" is prepared from the fruit elsewhere, the common varieties in Hawaii have never been extensively used in this way.

Of the various cooking plantains very little is known outside of the tropics. It is quite possible that when the value of the plantain becomes more generally known as a winter substitute for vegetables, its export from Hawaii will materially increase.

As is generally known, the varieties of bananas most useful to man seldom if ever reproduce from seed. They increase from suckers that spring up about the base of the plant. If allowed to grow undisturbed a single plant will soon develop a considerable clump, which may be divided and transplanted as desired.

The leaves are interesting, as the parallel veins stand at right angles to the mid-rib and are joined together to form the broad leaf. Heavy winds in many places tear the large leaves into shreds, hence a sheltered location is usually selected for the cultivation of the fruit.

The flower of the banana is somewhat unusual in appearance. Each plant bears but a single bunch of flowers which grows out of the center of the top of the stock on the end of the elongated spike. It appears first as a purple-red spike that curves downward as it grows. This spike-like head is made up of a large number of flowers grouped in clusters, each cluster later developing into a "hand" of bananas. As the clusters emerge they are covered by the thick, reddish bracts which curl up and expose the flowers. In time the tubular, cream-colored blossoms fall off, leaving the long ovaries. These in turn develop into fruits. Each bunch of bananas contains from one to a dozen or more of these clusters and each cluster from twelve to twenty-four bananas.

So far, the banana in Hawaii is fairly free from disease and pests. Three forms of fungus diseases are known to prey on the plant, but as yet they are nowhere serious. Two species of nematode worms are somewhat troublesome, and the cane borer, common throughout the group, has been occasionally found boring in the stem. The red spider, which is well known to most gardeners, has been instrumental in causing a brown smut to gain a foothold on the fruit.

Though this fungus has long been found on the fruit grown here, its effects are never serious.

The history of the development of the banana business is an interesting one, but it must suffice here to note that the first exportation of the fruit was made in 1864, when 121 bunches were shipped to the mainland.

Pineapples.

The pineapple[10] is a native of America, and is the most important member of the family[11] in which it is placed. This family has nothing whatever to do with either the pine or the apple families. The pineapple is a sorosis, or collection of fruits formed by the cohesion into a mass of the ovaries and perianths of the compact fruit. The flowers themselves are abortive. In the cultivated pineapple, seeds are rarely found, but the wild variety, from which it originated, has many seeds.

In Hawaii it is extensively cultivated, and was of early introduction. It seems well adapted to the islands and several varieties are grown, which produce fruit of the most excellent flavor. There are instances where the fruit has escaped or has been abandoned, where it is to be found growing in a wild state.

As is well known, the plant usually produces but a single fruit crowded in a rosette of stiff serrated leaves, on the top of the stem of the plant, which matures in from twelve to twenty months. The fruit is itself crowned with a cluster of stiff leaves. The plant is propagated by means of slips, suckers, crowns and rattoons. Over fifty well-defined varieties are recognized, some of them quite distinct forms, which vary widely in color, size and flavor. The most important species grown locally are limited to a few carefully selected types that are especially suited to the requirements of the canneries.

Fruits of the largest species not infrequently attain a weight of twelve or more pounds. The crop is harvested at certain seasons, but fresh fruit reach the market the year around. The plants are not entirely free from pests and diseases. The most serious disease, perhaps, is known as the "pineapple disease" of sugar-cane. This disease, which attacks the fruit causing it to prematurely decay and ferment, was first discovered on cane and received its name from the fact that it produced an odor in the decaying cane similar to that of the pineapple.

The Avocado or Alligator Pear.

The avocado, or alligator pear,[12] though technically a fruit, is from the culinary standpoint a salad vegetable, in that it is used much the same as the cucumber, since it is usually eaten with salt, pepper and vinegar. It is almost the only fruit which is eaten only as a salad. Persons who are served with this curious pear-shaped fruit for the first time are usually disappointed. But a just valuation of the rich nutty or butter-like flavor of the fruit is soon acquired, and once it is fully appreciated the taste becomes little short of a craving.

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[10] *Ananas sativa.* [11] *Bromeliaceæ.* [12] *Persea gratissima.*

The tree, which is a native of the American tropics, was of early introduction into Hawaii and is rapidly gaining in favor as an island fruit with a possible commercial future, which, however, has been somewhat interfered with through fruit quarantine measures that prevent its shipment to California for fear it may carry with it the much-dreaded fruit-fly that has already established itself in Hawaii.

The earliest known account of the avocado is found in Oriedo's report to Charles V. of Spain in 1526. At that time it was found growing wild in the West Indies, doubtless having been introduced there from the continent of America. In various places and in diverse ways the fruit has come to be known under no fewer than fifty names, no one of which is less suitable than the common English designation, since it is neither an alligator nor a pear, and moreover the combination of names is in no way pleasing, appetizing or appropriate. The fruit is justly entitled to a characteristic name, and avocado seems suited to the requirements.

In 1860 it reached Tahiti, and must have been planted in Hawaii very soon after that date. Trees about the city grow rapidly to a height of from twenty to sixty feet, and are at once identified by their large dark-green leaves and large pear-shaped, green and purple fruits, which contain a single large seed. The avocado belongs to the *Lauraceæ* and has such distinguishing relatives as the cinnamon,[13] camphor,[14] and sassafras,[15] all of which were introduced into Hawaii many years ago, but the avocado is the only member of the family that has been cultivated to any extent. As the fruit is usually grown from the seed, the quality varies with the different trees. Now the ripe fruits have been successfully shipped from Hawaii to New York and Washington, and as recent experiments have proved that choice trees can be propagated by budding, there is every reason to think that the avocado has a future before it, as it seems to be reasonably free from the attacks of the fruit-fly. Selected trees, sheltered from the wind and with other conditions favorable, have yielded as many as 250 fruits to a tree, while the yield from exceptional trees has been more than a thousand pears.

PAPAYA.

Like the foregoing, the papaya[16] is a native of tropical America, probably Brazil, and is a fruit much esteemed in the islands. It is one of the commonest fruits in many private yards, and considered as a fruit, vegetable, salad or simply as an ornamental plant, it is a general favorite. Its large, golden, melon-shaped fruits and handsome, thrifty, green, palmate leaves render it a species that attracts attention at once from strangers.

By some the fruit is called papaw, a name which should perhaps be reserved for the tree and fruit of *Asimina trilola*, which is a tree common throughout the southern United States. It bears smooth, oblong fruits that in no way resemble the papaya of the tropics. They are three or four inches long, banana-

[13] *Cinnamomum Zeylanicum.* [14] *Cinnamomum camphora.* [15] *Sassafras officinale.*
[16] *Papaya vulgaris* = *Carica Papaya.*

shaped, and are filled with sweet pulp in which are embedded the bean-like seeds.

The papaya is an interesting example of a diœcious plant, as it has the male and the female flowers on separate plants. The edible fruit is produced by the female tree, as a rule. It is therefore desirable, in order to insure the best crop of fruit, to plant a number of trees of both sexes in close proximity.

There are a number of varieties under cultivation, all of which are known locally as papaya. While it is usually a small, short-lived tree with a single, stout, unbranched trunk, crowned with a cluster of leaves, there are many old specimens thirty feet or more in height that so differ in appearance that only the characteristic leaves prevent them from being mistaken for some rare species of curious tropical plant.

It is extensively grown in the tropics, and may now be found wherever climate and conditions are favorable. The milky juice of the plant has a property similar to, though different from that of pepsin. If tough meat is wrapped in the fresh leaves for a short time it will become tender. The seeds also possess valuable properties as a vermifuge.

Guava.

Several species of guava thrive here. They grow from seed so readily and spread so rapidly that the lemon-guava,[17] at least, is no longer cultivated. In many sections this species forms dense thickets. As it fruits abundantly at nearly all seasons at different elevations it furnishes a refreshing fruit that may be enjoyed on mountain rambles.

Of the 130 species known several are well established in Hawaii, but aside from the common lemon-guava and the smaller red strawberry-guava,[18] the other species are rarely met with. The fruit is supposed to be more agreeably acid and hence more palatable if gathered in the early morning. The lemon-guava, besides being a rich, aromatic fruit, makes fine jam, guava whip, and jelly, the latter being one of the finest-flavored jellies known. In spite of this fact comparatively little of it is manufactured, and thousands of tons of the fruit waste every year. This acid vegetable material, however, when added to the lava soils of Hawaii is a decided benefit to the land. Since the bushes grow on all kinds of soil under widely varying conditions the wedge-work done by their roots has proven a decided help in opening up the more resistant soils.

Lemons, Oranges and Limes.

The orange[19] is one of the oldest of cultivated fruits; although its nativity is not known, it probably originated in the Indo-Chinese region. It is now widely distributed and just whether it was introduced into these islands by the natives themselves or by the earliest explorers will probably not be definitely known. Vancouver is generally accredited with its introduction, as in 1792 he came from Tahiti, where it had long grown, having received a large store of supplies from the natives there. Arriving on Hawaii he left with the native

[17] *Psidium Guayava.* [18] *Psidium Cattleyanum.* [19] *Citrus Aurantium.*

PLATE 70. HAWAIIAN FRUITS.

1. Dates (*Phoenix dactylifera*). 2. Wi (*Spondias dulcis*). 3. Grenadilla (*Passiflora quadrangularis*). 4. Papaya (*Carica Papaya*). 5. Breadfruit tree [Ulu] (*Artocarpus incisa*). 6. Lemon-Guava (*Psidium Guayava*).

chiefs of Kona a number of valuable seeds and "some vine and orange plants." A few days later he left some "orange and lemon plants" on the island of Niihau. It is supposed that these plants were the parents of the famous russet Kona oranges that are such general favorites among islanders. On Molokai, far back in the mountains, a few years ago I found an old orange grove in a fairly thrifty state, in which some of the trees were two feet in diameter at the height of my shoulder. Everything about them indicated their great age, and it is highly probable that this grove antidates the introduction of the plants by Vancouver.

Oranges, lemons,[20] limes [21] and the grape fruit, pomelo or shaddock,[22] have all found an equally congenial home here, and there are many Hawaiian varieties, and seedlings that lack names but that, nevertheless, are excellent and point to the fact that our soil is well adopted to their growth and culture. As is to be expected, the citrus fruits are here, as elsewhere, subject to a number of pests. Many of them are in an unchecked state and can do much damage. Among them are root-rot or gum disease affecting the trunk; ripe rot, due to a fungus attacking the fruit, and sooty mould, causing the blackened or mouldy appearance of the leaves, fruit and twigs. It is interesting to know that this last disease does not feed on the tissues of the plant, but thrives on the sweet dew-like substances deposited by aphids and scale insects. Lichens in moist localities; 'die back,' [23] and lemon scab [24] are among the more common diseases.

Among the insect enemies, the purple scale is quite prevalent. It may be readily identified, when adult, as a purplish object shaped somewhat like a miniature oyster shell. A species of mealy bug, appearing as a cottony mass, occurs in the terminal twigs causing them to grow twisted. The orange aphis or black fly is a minute insect living in the fine twigs. And lastly, the orange rust mite, which, though very tiny indeed, is the cause of the russet oranges. It pierces the surface of the fruit and feeds on the oils therein. The same species affecting lemons causes them to turn silvery. It is a curious fact that fruits affected by this mite are usually better flavored than those that are not troubled by it, though they are less attractive in appearance. The most serious pest of all, however, is the recently-introduced Mediterranean fruit-fly, elsewhere described at length.

The lime is extensively grown, there being several local varieties. The supply at present is almost sufficient for the local demand. The citron [25] is generally grown in yards and gardens. Both the oblong and round lemon-like kumquat [26] thrive, as does the shaddock, which is recognized by its size (six or seven inches in diameter) and coarse texture. All of the foregoing have long been cultivated and are found in deep valleys in such a wild state that they might almost be considered as part of the native flora. The pomelo deserves more care than has so far been bestowed upon its culture. Several of the Japanese

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[20] *Citrus Limon.* [21] *Citrus acida.* [22] *Citrus Decumana.*
[23] A disease traceable to unfavorable condition in the soil.
[24] Cone-like elevation on leaves, fruit and twigs.
[25] *Citrus Medica.* [26] *Citrus Japonica.*

and Chinese types of oranges bear astonishingly well, and should the trees be more intelligently and extensively cultivated they would yield even more abundantly.

The wi or Tahiti apple [27] has a golden fruit that grows in clusters, on a tree resembling the walnut in appearance. The fruit, which is the size of a peach, and has a curious seed, somewhat suggests the pineapple in flavor. It is a native of the South Pacific islands and is now widely distributed in the tropics.

The Custard Apple and Its Allies.

The custard apple genus,[28] of which more than fifty species are known, is represented in the islands by at least three common species that occur here and there, usually as ornamental trees or curiosities in door-yards about the islands. Included in this genus is the sour sop.[29] It comes from the West Indies, where it is a favorite fruit. This thrifty green tree bearing a large conical heart-shaped, green, spiney fruit, six to eight inches long and weighing as much as five pounds, will be recognized at once by the novice. The white, soft, juicy, sub-acid pulp of the fruit is used to some extent as a flavoring for sherbet and fruit punch.

The sweet sop [30] bears a fruit resembling a short pine cone in shape that is three or four inches in diameter, yellowish-green and tuberculate. The pulp is creamy-yellow, custard-like and very sweet.

The custard apple,[31] a smooth fruit, is also a favorite in the West Indies, which is probably its home. Both the custard apple and the sweet sop are worthy of more attention in Hawaiian gardens.

Cherimoya [32] is a thrifty tree coming originally from Peru, but now widely naturalized. It is of comparatively recent introduction into Hawaii, the fruit coming mostly from Kona. The fruits are slightly flattened spheres, two or more inches in diameter, brownish yellow in color with the flesh soft, sweet and rich in flavor. It is a well known fruit in the tropics. All three of the Anonas just mentioned are easily propagated from seed and thrive in ordinary heavy soils.

The sapodilla,[33] a tree of Central America, is much esteemed under the more common name of Sapota pear. The fruit is the size and color of a small russet apple. It is a firm fruit with ten or twelve compartments and as many large black seeds. The flesh is sweet and pear-like in flavor. From the sap of the tree chewing-gum is made.

The loquat [34] or Japanese plum, a native of China and Japan, is a small tree with thick, evergreen, oval-oblong leaves that are covered with rusty hair beneath. It bears well in Hawaii, usually producing two crops each year, and is an excellent decorative fruit. The pear-shaped fruit is yellow with large seeds and has a pleasant flavor. It is extensively planted in southern California and elsewhere in the southern states.

Figs, Grapes and Mulberries.

Several varieties of figs [35] are grown here, and but for the attacks of birds

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[27] *Spondias dulcis.* [28] *Anona.* [29] *Anona muricata.* [30] *Anona Squamosa.* [31] *Anona reticulata.*
[32] *Anona Cherimolia.* [33] *Achras Sapota.* [34] *Eriobotrya Japonica.* [35] *Ficus Carica.*

and insects would flourish. The fig, as is well-known, is a native of Asia . It is a true *Ficus,* belonging to the same genus of plants with the ordinary rubber tree or banian common in the islands. Several varieties of the choice Smyrna fig have been introduced recently, together with the interesting wasp which is necessary to fertilize the flowers. The story of the development of the Smyrna fig industry in the United States is one dealing with a remarkable triumph of economic entomology and is a tale of absorbing interest.

Grape culture is carried on to some extent in a commercial way, especially by the Portuguese. Although the grape [36] has been cultivated by man since the beginning of history, it was unknown in Hawaii before its introduction by the whites, which took place at an early date. The Isabella is the type of blue grape most cultivated and is to be had in the markets throughout the year. All species grown are subject to the attacks of insects, the most important pest being the Japanese beetle. This insect is especially troublesome, often completely defoliating the vines.

Certain varieties of apples [37] have been grown in the islands at high altitudes, though they seem to require a different climate. Peaches [38] thrive fairly well in the islands. While not producing fruit of marketable appearance or flavor, it seems to be bound to no set season, blossoms and fruit being found at different elevations, and under varying circumstances, the year around.

The black mulberry [39] was early introduced into the islands for the purpose of supplying food for silk worms. It was hoped by the missionaries that the silk industry might be established among the natives. Interest was allowed to lapse, however, though the mulberry does well here, having escaped into a wild state in many sections. The white mulberry [40] has also been introduced. Should fruit-eating birds be extensively introduced it would doubtless be spread by them into the mountains generally.

EUGENIA.

Of the large genus of *Eugenia* [41] many species have been introduced into the Hawaiian islands. Of the fruiting shrub-like bushes seen in yards, the Cayenne or Surinam Cherry [42] is most common. It is a native of Brazil, is bush-like in growth, seldom if ever growing more than twenty feet high. It is easily identified by its dark red edible cherry-like fruits which are an inch in diameter and ribbed from the stem to blossom end. The delightful, spicy, acid flavor of the fruit is characteristic. Elsewhere it is much used for jellies and jams, and is sometimes improperly called the French cherry.

The rose apple,[43] another Eugenia, is also frequently seen in gardens in the group. It is a tree usually attaining the height of twenty or thirty feet with long, thick, shiney green leaves much resembling the oleander. The fruit, which has little to recommend it as a fruit, is white or yellowish in color, tinged with a

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[36] *Vitis* spp. [37] *Pyrus Malus.* [38] *Prunus Persica.* [39] *Morus nigra.* [40] *Morus alba.*
[41] Named in honor of Prince Eugene of Savoy. [42] *Eugenia Michelii* = *E. uniflora.*
[43] *Eugenia Jambos.*

bluish blush and is an inch and a half or more in diameter. It is peculiar in being rose-scented and apricot flavored. Another species of Eugenia that is an especially prolific bearer is known locally as Java plum.[44] The tree grows thirty or more feet in height and bears a wealth of black fruit the size of a small plum; they are quite common in gardens in the islands. The mynah birds are fond of the fruit and may be seen carrying it about when it is in season. Flying to the nearest house-top or fence post, they eat the flesh off allowing the hard seed to fall and take root as it will.

The Passion Flowers.

Of the great order *Passifloraceæ* or passion flowers, a number of species are in cultivation, some of them producing fruit of a remarkable quality. The passion flower[45] proper, is a slender vine coming originally from Brazil. It is perhaps the most common garden species. The leaves are deeply divided into five segments, the lower two being sometimes again divided. The flowers are three to four inches across and slightly fragrant. It is interesting to know that the Spanish, when they found this flower growing in the South American forests, took it as a token that the Indians should be converted to Christianity. They saw in its several parts the emblems of the passion of our Lord, hence the *flos passionis* was described as early as 1610 as a marvel of prophetic beauty, and properly enough the description then made has been the foundation for the name of the whole group of plants.

The devout, or those gifted with a fertile imagination, find in the various parts of the blossom, the crown of thorns; a blood colored fringe suggesting the scourge with which the Master was tormented; the nails; five blood stains, standing for the wounds received on the cross; the fine filaments, seventy-two in number, agreeing with the traditional number of thorns with which the crown was set, and lastly the lance-like leaves of the plant referring to the instrument which pierced the Savour's side. The leaves are also marked beneath with certain spots suggesting the thirty pieces of silver.

But to return to the fruits belonging to this order, the species most commonly seen in the market is the egg-shaped water-lemon.[46] This is an edible fruit yellow in color, spotted with white, the seeds having a sweetish, cool pulp about them with a delicate and, to many, pleasant flavor. The flowers are about two or three inches in diameter; the leaves entire with a short, sharp point.

The purple-fruited water-lemon or lili koi,[47] is also common, having escaped to many places about the islands. The ganadilla,[48] the largest of the passion fruits, is a most remarkably strong-growing climber introduced from tropical America. The large leaves three to five inches across, and the long yellow-green melon-shaped fruit, often nine or ten inches in length, make it a striking plant. The fruit is edible, being used to advanatge as a flavoring for sherbets.

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[44] *Eugenia Jambolana = Syzygium Jambolana.* [45] *Passiflora cærulea.* [46] *Passiflora laurifolia.*
[47] *Passiflora edulis.* [48] *Passiflora quadrangularis.*

Pomegranates.

Pomegranates [49] are grown throughout the islands in gardens, more as ornaments than for the fruit. Their bushy growth and awl-like spines and narrow, glossy-green leaves, with red petioles, make it conspicuous. The fruit is globular with a bright, smooth, yellow, red-blushed rind and a prominent crown-like calyx. The interior consists of a number of seeds enveloped in a bright crimson-colored pulp, the seeds being crowded into several segments. The cooling, astringent juice of the pulp is enjoyed by many. The pomegranate, a native of Asia, is supposed to have been introduced into southern Europe by the Carthagenians at a very early date, and has from there been widely distributed. There are several varieties grown in Hawaii, among them a double flowering variety that is quite popular as an ornamental plant.

We could extend the list of fruits and fruit-like products indefinitely. The lichi [50] of China; the mangosteens [51] of China; the water-melon [52] of Africa; the musk-melon [53] of southern Asia; the fruit of the prickly-pear [54] from Mexico, are all to be seen among the fruits in the Honolulu markets. In fact, a list enumerating considerably over one hundred well-defined species of fruits occurring in Hawaii has been prepared, and it is safe to assume it could easily be extended; a number of the rarer fruits receive brief notice in the index.

CHAPTER XX.

AGRICULTURE IN HAWAII: ITS EFFECT ON PLANT AND ANIMAL LIFE.

The remarkable agricultural transformation of the Hawaiian Islands, from the time when taro-growing was the chief occupation of the primitive inhabitants, to the present, when the growing of sugar-cane is the dominant industry of the land, furnishes a story filled with facts of the greatest interest. The account of this transition, however, would come more properly within the scope of a political and industrial history of Hawaii. Nevertheless, agriculture, in the broad sense, is a natural employment, having to do with plants and animals. It has been, and doubtless will always continue to be, the chief vocation of the people of the islands, and as agriculture and the occupations growing out of its practice will long continue to be the main source of prosperity and wealth, a brief account of the natural, as distinguished from the commercial history of some of the industries, at least will not be out of place here.

Agriculture in Recent Times.

Our present interest in the subject, however, comes mainly from the fact that the phenomenal development of agriculture in Hawaii in recent times has

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[49] *Punica Granatum.* [50] *Nephelium Litchi.*
[51] *Garcinia mangostana* from Sumatra; also the more common *Garcinia xanthochymus* from India.
[52] *Citrullus vulgaris.* [53] *Cucumus Melo.* [54] *Opuntia Tuna.*

PLATE 71. MINOR AGRICULTURAL INDUSTRIES.

1. Taro ponds at the head of Manoa Valley. 2. Coffee berries; one-half natural size. 3. View on a sisal plantation; gathering the leaves, the first step in securing the fiber. 4. General view over recently planted rice plantation; beyond the first headland the smoke from a plantation trash fire may be seen. The walled enclosure in the first bay is a mullet pond. 5. Picking coffee.

not only brought in a host of both beneficial and injurious plants and animals from abroad, but through tillage, has brought about changed conditions in the natural environment. These sweeping changes have affected the primitive natural history of the Hawaiian Islands more than all other agencies put together.

Enormous areas of land have been cleared of the natural growth of forest and field and usually put under artificial irrigation, with the result that more radical changes have been made in the character and use of the land of the islands, in one generation, than was brought about by the operations of the primitive inhabitants during the whole period of their occupation of the group. Such wide-spread changes in the character of the country have been reflected in numerous remarkable changes in the native fauna and flora. In numerous instances, the extension of agriculture must be credited with the extermination of many forms of life formerly common in such sections as are adapted to the purposes of the planter and the ranchman.

The Sugar Industry.

Foremost among the industries of this class is the production of sugar. All other field crops dwindle to insignificance in comparison with it. Few places in the islands where cane can be grown at all, will yield less than thirty or forty tons, and from that up to sixty and seventy tons to the acre. Such a yield of green stuff can hardly be obtained from any other farm crop, and the development of the industry has been as remarkable as the yield.

Cane is now cultivated extensively on the four main islands, being planted from near the sea-shore up to elevations of about two thousand feet. As a rule, however, it is the rich lands skirting the islands up to 500 feet that constitute the chief sugar-growing sections. The maximum area that can be put under cultivation for this crop has been about reached, there being approximately 80,000 acres now planted to cane which yield on the average about 500,000 tons of raw sugar annually. The yield per acre varies greatly according to the character of the soil, and the position of the plantations, whether in rainy or rainless regions, the amount of fertilizer employed, and so on.

Under favorable conditions ten and a quarter tons of sugar have been the average yield for an entire plantation; while single acres have given much higher yields. Some lands less favorably located fall far below this yield. Next to soil and climate, one of the most important factors in the production of a good crop is the amount and character of the water used. Salt in the water, if in any considerable amount is detrimental, and often conditions are such that one hundred grams to the gallon would absolutely prevent the plant's growth.

As to the original introduction of sugar-cane into Hawaii, little is known. There are writers who think the islands in the south Pacific were the original home of the sugar-cane, since there are peculiar species there that are found nowhere else. It is argued that the plants were introduced from there into Hawaii by the natives. But the cultivation of cane has been carried on so long in widely distributed regions that the real home of the plant is lost in antiquity.

The probabilities are that it was used by man ages before there was any record of the fact, and that its culture and use as food in a raw state were among the first agricultural efforts of any tropical people.

The invention of the processes for extracting the juice and converting it into sugar or molasses has long been practiced, but only during the last century has it been brought to a high state of scientific perfection. The plant is now grown under such exacting conditions and handled by such a great variety of special mechanical devices, and the sugar extracted by such intricate methods, that it is doubtful if there is another plant grown that has been more exhaustively studied and exploited.

The plant,[1] as is well known, is a gigantic perennial grass with heavy maize-like stalks that grow from eight to twenty feet tall. Unlike most members of the grass family the stems are solid and contain an abundance of sweet juice.

The many varieties of cane have different sugar-producing qualities that cause one kind to be substituted for another owing to their adaptability to peculiar soils. The varieties vary usually in the color of the stem; being yellow, purple, green and variously striped. Five well recognized types of cane are extensively grown in Hawaii, though there are numerous varieties of doubtful scientific value. The chief types are the Yellow Otaheite; the Cheribon or Wray's Batavian; the Tanna, the Salangore and Cavengerie canes.

The cane leaves are about two inches in width by three to five feet in length. The flower stem is pampas-like, silvery-gray, or mauve, in color, and when in blossom the field is strikingly beautiful.

While cane had long been used in the islands, it was not until about 1828 that it was first made into sugar. Its culture was not really begun, however, until about 1850, when with crude wooden and stone mills and inferior boiling kettles a yield of one ton of low-grade sugar per acre was secured.

Since then all of the resources of science have been brought to bear on the production of sugar, with the result that today Hawaii leads the world in the scientific production of this valuable commodity. By experimentation, many kinds of soil have proved suitable to the growth of cane. Those preferred are the deep sedimentary deposits common in the lower zone or cane-belt of the islands. These deposits, varying in thickness from one to fifty feet, have been derived from the normal lavas that have undergone decomposition and disintegration in the warm and often dry climate of the lower coastal zone. The process of erosion has been actively at work on them for ages. Such soils are mainly red in color, owing to the great amount of iron they contain. The most fertile of these soils are usually those that have been darkened as the result of the decay of vegetable matter.

The first step in preparing the land for cane, or, indeed, almost any crop, is to clear it of all trees, shrubs and stone, and render the surface as level as possible. Plowing is then undertaken. This may be done by mules or oxen,

[1] *Saccharum officinarum.*

or by huge steam plows. Where the character of the country will admit, the latter method is the one generally preferred.

The machinery consists of large, double gang-plows that are drawn back and forth across the fields by wire cables that wind and unwind from large drums operated by traction engines located at opposite ends of the field. In this way five or more furrows sixteen inches wide by twelve inches deep are turned over at once. The field is then plowed crosswise of the furrows. Occasionally a giant plow that opens a furrow thirty inches deep is employed to reach the subsoil. The plowing done, the ground is allowed to fallow for several weeks. After it has thoroughly weathered, it is harrowed to break up the clods and level the surface; a heavy drag is sometimes used for the purpose.

If the crop is to be grown by irrigation, the main ditch lines are next laid out by the plantation engineers. The trunk ditches or main flumes usually remain in the same place from year to year, and are frequently walled with stone or wood, and often are cut through the solid rock. Where they cross gulches or are raised above the ground for any purpose, the flumes are made of wood or metal, and much skill and money has been expended in these preliminary operations in many sections. Water, which is the life of the land, is transported in large quantities for long distances in this way.

The secondary ditches are next laid out in such a way that water may be made to flow along every row of cane on the plantation. The furrows in which the cane is planted are made by a curious double plow which is so constructed that it will throw the earth both ways, forming ridges between the furrows. These furrows are made from eight to twelve inches in depth, and from four to five feet apart.

Sugar-cane is propagated by cuttings called seed-cane. Each seed joint must have one or more living buds. To insure sufficient buds they are usually cut in sections having two joints to the piece. These pieces are dropped into the furrows, a few inches apart, by the planter from a bag carried on the shoulder. The seed cane is then covered an inch or two deep with soil and water turned on. In about a week the cane sprouts. From that time on the growing crop is hoed and watered as required. Often loose soil is drawn over the moist earth from the ridges between the rows to prevent the rapid evaporation of the water; but the processes of cultivation vary widely on different plantations.

Several times during the growth of the crop the cane is stripped of the dead leaves to prevent the water from being held along the stalks and souring the juice. The bundles of leaves are piled on the ground under the tangle of growing cane to support the stalks.

The age at which the cane matures varies greatly, but ranges from one to two years. The tassel is the index that tells when it is ripe. The crop should be cut as soon as possible after it is through blooming, as the juice is at its best at that time.

In harvesting the crop the stalks are cut and trimmed in the field, the

PLATE 72. THE MILLING OF SUGAR CANE.

1. High flume across a gulch on Hawaii. 2. Hauling cane to the mill with a traction engine. 3. Plantation machinery and a sugar mill. 4. Type of evaporating pans in general use. 5. One method of gathering sugar cane. 6. Plantation scene. The mill at Aiea. 7. Diagram of the process of milling sugar cane.

refuse and trash being left on the ground to be burned later on. The trimmed stalks, which average eight or ten feet in length and more than an inch and a half in diameter, are loaded upon carts or cars drawn over portable tracks by horses or by small locomotives. Where there is a surplus of water the cane is often floated to the mill in the flumes. In this way the water flumes are utilized in the production and harvesting of the crop in both wet and dry districts.

The loaded car on arriving at the unloading shed is brought alongside a moving floor that, in reality, is a wide endless chain-belt that carries the cane to the elevator. The cane in most cases is unloaded by machinery that pulls the load from the car to the moving floor. From the floor the cane is elevated on a conveyor which delivers it to a pair of large corrugated rollers that crush the stalks, extracting much of the juice. The crushed mass is then passed through several sets of rollers, each set made up of three close-fitting cylinders. In the final crushing process, hot water is added to aid in extracting the last particle of juice that may remain. The dry mass, now called "bagasse," is carried on elevators to the furnace room, where it is used at once for fuel.

The juice from the rollers is collected and conducted to the liming tank, where a chemical change is effected by adding slaked lime. From a receiver near the liming tank the juice is passed to the settling tanks.

After it has stood a few hours, the juice of the top portion is drawn off and the muddy lower portion agitated by steam. This hot mixture is then passed to the mud presses, where the clean juice is separated from the mud. The liquid mixed with the clear juice from the settling tank is next conveyed to the evaporating pans, where it is changed by heat from juice into syrup.

The evaporators are a series of four or more large iron boilers connected one with the other. The air is removed from them in order to create a partial vacuum. The juice will then boil with less heat and the syrup is prevented from scorching. The syrup, when sufficiently reduced, is conveyed to the vacuum pans, where the grain in the thick molasses is produced by another boiling.

At this stage inventors have made many improvements in the process by which the thick mass is passed into the crystallizers, where the syrup or sucrose is made into firm, dry grains. Small amounts of syrup are transferred to the tub-like machines called centrifugals. These tub-shaped cylinders have central cavities made of wire netting. This wire cage revolves rapidly and by centrifugal force throws the molasses out, retaining the crystals of sugar within the cage. The uncrystallized liquid is carried to the boilers again and is made into second-grade sugar. The higher grade sugar drops from the centrifugals into a large retort known as the drying machine. Through this the sugar works its way among hot coils that dry the crystals before they are carried to the sugar bin. From this bin the raw sugar is drawn out, sacked and weighed. Each burlap sack contains about 125 pounds of light-brown sugar.

Most of the sugar is sent as light brown, or raw, sugar to the mainland of

the United States to be refined or purified. One mill on Oahu, however, produces refined white sugar. In the refining process it is melted and boiled again, and at the same time is chemically treated, the crystals becoming pure white and transparent. It is in this condition that it is sold everywhere as granulated sugar.

Rice.

Next to sugar and pineapples, rice[2] is the most important field crop in Hawaii. Although the most primitve methods are practiced in its cultivation and milling, the annual product, from the ten thousand or more acres under cultivation, reaches as high as ten million pounds a year. Five crops can be grown on the same land in three years, the annual yield per acre being about eight thousand pounds. The crop is grown almost exclusively by the Chinese on leased lands, for the use of which they pay an annual rental ranging from ten to fifty dollars per acre. Their methods of propagation, culture, harvesting and milling are extremely crude; they are, nevertheless, interesting and picturesque.

The rice plant is the only important economic species belonging to the genus of grasses *Oryza*. It is said to furnish food for one-half of the human race. The plant seems to have been originally a native of the East Indies, probably being first cultivated in India. From that region it has spread to all quarters of the globe where conditions are favorable. Our Hawaiian rice, so called, is thought to have been originally derived from a South Carolina stock, as the first rice cultivated here was obtained from that state. It has since been mixed with a number of other varieties, however. Somewhat extensive experiments under the direction of Professor Krauss have been made in recent years with a view to introducing improved varieties. It is said that there are more varieties of rice known than of any other crop, there being more than a thousand varieties in India alone.

The plant is an annual, growing from three to five feet high in Hawaii, according to variety and conditions. The seeds or grains grow on little stalks springing from the main stalk, and when ripe, the appearance of the plant is between that of barley and oats. Rice in India is known as paddy. The term is also used to designate the rice in the husk, and in Hawaii the small shallow ponds in which it grows are called paddies.

Rice is grown in Hawaii by what is known as the Oriental method of culture. The seeds are planted in carefully prepared seed-beds that are kept moist but not flooded. After the seed has germinated and is three inches tall, the ground is kept flooded until the plants have reached a height of six to ten inches. They are then pulled from the muck and water and the roots soundly beaten on a board; the object being to prune back the root sprouts. The seed plants are topped and tied in convenient size bundles and taken in large baskets on shoulder poles to the field to be planted. The advantage of this

[2] *Oryza sativa.*

method of planting is that a more uniform stand may be secured, resulting in a larger yield in a shorter time.

The small fields, which are arranged so they can be flooded with water, have been previously prepared by plowing six or seven inches deep. The water cow,[3] known also as water buffalo or carabou, is used in the plowing operations as a general rule, but occasionally horses are employed. After plowing, the earth is covered with water and a curious harrow used until the soil is reduced to a fine, thick mud. It is next covered with water to the depth of an inch or two, when it is ready for planting.

The planting is done by hand. The bunches of seed rice are distributed over the paddies at convenient intervals along straight guide-lines set out across the patch. The entire force of field hands rapidly plants out the shoots by sticking the sprouts in a straight row ten or twelve inches apart, with six or eight inches between the plants in the rows. The plants tiller or spread from the roots, so that each root planted sends up many stalks.

After the plants are set, the field is kept flooded with water, the depth of the water being increased somewhat as the plants grow. When the crop is about fifteen inches high the field is gone over to weed, thin and transplant where necessary. At this stage the wild rice,[4] which is found wherever rice is cultivated, is pulled up and destroyed. It differs from the cultivated rice in being a coarser type with deeper green leaves and in having fruit which has large awns. The wild species falls to the ground as soon as it is ripe, thus seeding itself before the regular crop is harvested. As it thrives on the same treatment as the commercial species and spreads its seed broadcast, it is by far the worst weed in the rice fields. When compared with other crops, however, rice is singularly free from pests and diseases, and produces a remarkably full and uniform yield, year after year.

The water is allowed to remain on the ground until about ten days before the grain is fully ripe. The ripening period is generally indicated by the heads bending over from the weight of the heavy grain. From the time the head begins to form, a period marked by the peculiar odor given off by the opening glumes, to the final gathering of the grain, the fields are guarded from dawn until dark, by the planters, to prevent the three introduced pests—the linnets or rice birds; the weaver birds, and, to some extent, the English sparrows—from destroying the crops. In spite of their vigilance, considerable quantities of the maturing grain are consumed or spoiled by the birds, especially when the rice grains are in the milk stage.

The harvesting of the golden-yellow crop is indeed picturesque. There are usually a dozen or more Chinese engaged in the operation. The grain is cut once near the ground, with reaping hooks, then mid-way of the straw. The grain portion is laid in neat straight piles on the coarse straw or bound into good-sized bundles and left to cure. When sufficiently cured the bundles

[3] *Bos bufalus.* [4] *Zizania aquatica.*

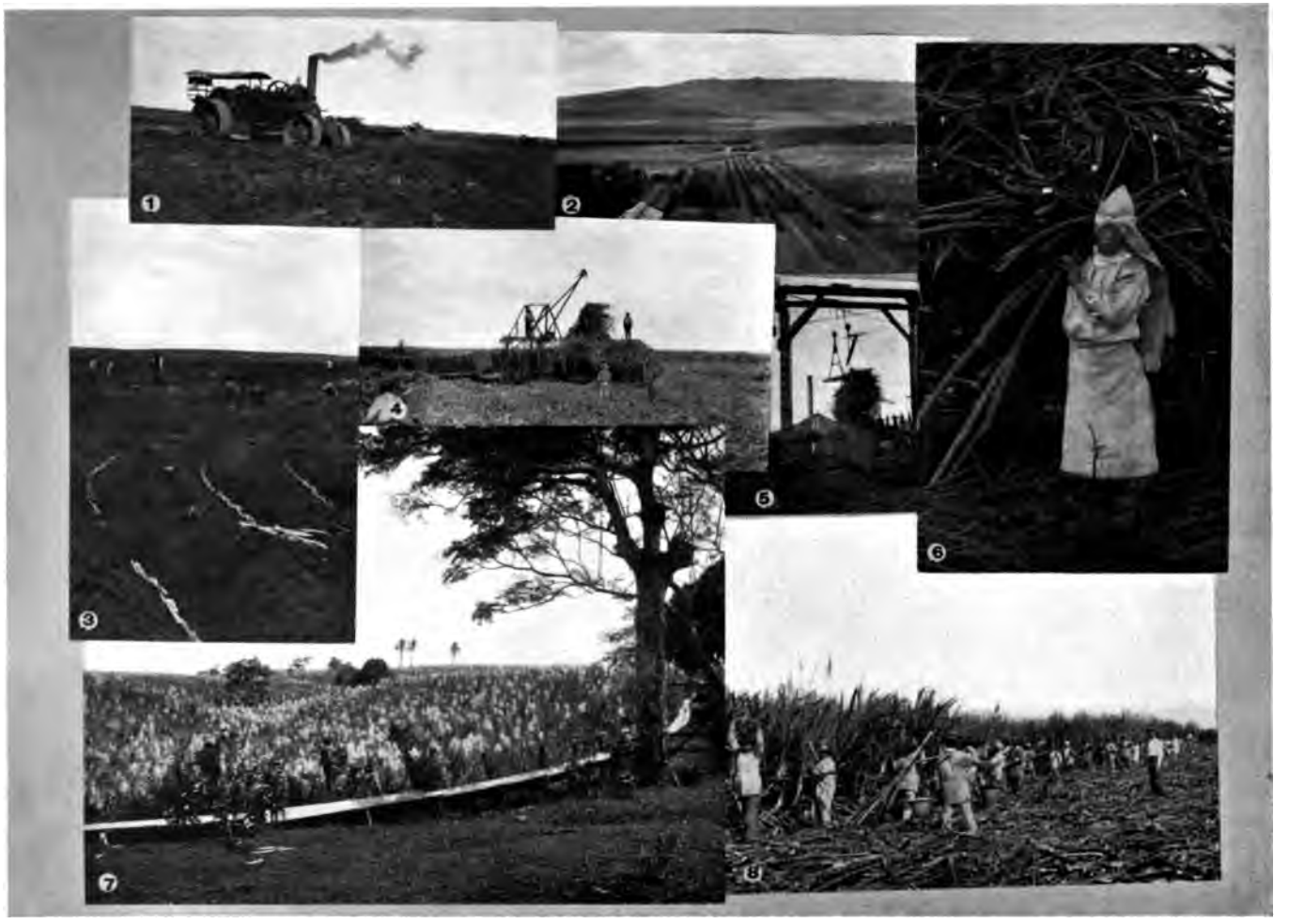

PLATE 73. PLANTING AND HARVESTING SUGAR CANE.

1. Plowing with a double gang plow and two engines. 2. General view of a plantation; cane cars on the siding in the foreground. 3. Planting seed cane. 4. A patent cane loader in operation. 5. Unloading device at the mill. 6. Loading cane onto flat cars. 7. Field of cane in blossom ready to harvest. 8. Cutting and stripping cane.

are carried, a few at a time, on each end of a carrying stick over the shoulder, and stacked near the thrashing floor and mill.

The grain are tramped out in the most primitive fashion by horses on a smooth, hard floor. It is further dried on the floor and is then stored in sacks.

The removing of the hull or husk is a laborious task, occupying hours of time and all the machinery that the ingenuity of the Chinese race has been able to bring to bear on the problem. The process, to be appreciated, is one that must be seen in its primitive crudeness at the mills themselves, where the Chinese miller, cheerfully explaining the operation in answer to every question, blandly replies, "Oh, Chinaman, him long time do alle same, me no sabbie." However, it should be remarked that a few of the more progressive rice growers are making use of some of the modern American machinery, and it is quite probable that before many years the change in methods of growing and milling will be complete.

COFFEE.

Coffee growing is essentially a tropical industry, and the coffee[5] plant has found a favorable home in the higher districts in the Hawaiian Islands. The industry, for various industrial reasons, has not prospered of late as it should. The plants were first introduced into the islands in 1823 by Mr. Matain, who established a small plantation near Honolulu. Coffee was again introduced from Rio de Janeiro, in 1825, by Mr. John Wilkinson, a practical gardener, who came to the islands from England in the ship Blonde at the request of Governor Boki. He settled in Manoa Valley, where he made a beginning in both the sugar and coffee industries. Plants from there were set out in Kalihi, Pauoa and Niu valleys. A year or two after (1827-28) plants were introduced from Manila and were also set out in Manoa Valley. From this start coffee plants soon spread to other localities throughout the group, and there are trees in existence over sixty years old that are still in a thrifty condition.

The plant without question is a horticultural success in the islands, attaining an early maturity and bearing heavy crops. The berries are frequently so crowded on the stem that there is scarcely room for one more. The coffee of the islands has a marked flavor, and pure "Kona" is said to be superior in every way to the best Mocha or Old Government Java.

The coffee plant was first cultivated by the Arabs, who transferred it from its native soil in eastern Africa to Arabia, about the 16th century. From Arabia it was carried to Batavia, the capital of the Dutch East Indies, a hundred years later. From this beginning many cultural varieties have been developed that are now grown in the coffee zone throughout the world.

In a wild state coffee is a slender tree and grows fifteen to twenty feet in height, but in cultivation, for convenience in picking the fruit, it is not allowed to grow over ten or twelve feet tall, and the tree is made to assume a pyramidal

[5] *Coffea Arabica* and *C. Liberica*.

form. The leaves are evergreen and leathery; the flowers are small, snow white and fragrant, and the whole appearance of the tree is so very pleasing that they are frequently grown in gardens and elsewhere as ornamental shrubs. The fruit when ripe is of a dark scarlet color, and the seeds are horn-like and hard. The seeds are usually called coffee-beans. Not that they are beans at all, but because of the Arabic word "bunn," which means coffee.

The berries are very unequal in ripening. In Hawaii three or more pickings are made annually. There are different methods of curing the berries. By the old method the fruit is placed on floors especially adapted to the purpose and allowed to dry in the sun. It is then passed between rollers to remove the dried pulp of the bean, and the membrane which encloses the seeds themselves. The coffee is afterwards freed from impurities by winnowing machinery. By a new method the berries are freed from the pulp and their coverings by maceration in water, with the aid of a pulping machine. The beans are sometimes subjected to polishing.

Three types of coffee are in cultivation in Hawaii, namely, the Hawaiian, of the original introduction—a very hardy type; the Java, brought directly from Java; and Horner's Guatemala, a variety supposed to have been introduced from a Javan source, but nevertheless of uncertain origin. However, the latter variety is the most extensively cultivated, being a hardy, heavy bearer and not subject to disease. It bears a large, flat berry resembling the best types of imported Java coffee.

Sisal.

The growing of sisal[6] has attracted considerable attention on the island of Oahu, where several hundred acres are now planted to this crop. The plant not only grows luxuriantly on the better lands, but does well on land not suited to other field crops. Sisal was first introduced and widely distributed for trial in 1892. It has been found to thrive from sea level to three thousand feet elevation, and to be especially suited to the lee or dry side of the islands. The species is a native of Central America and closely related to the century plant.[7] As a source of cordage it yields a fiber second only to Manila hemp in strength. Its smooth, straight strands of fiber are obtained by decorticating the leaf. The life of a shoot, if undisturbed, is six or seven years, after which period it sends up a blossom stalk as high as twenty-five feet, and then dies. Cutting the leaves for fiber, however, extends the life of the plant several years.

Other Fiber Plants.

Manila hemp, secured from a species of banana,[8] has been grown experimentally in the islands for a number of years, and is reported from various localities. It was introduced from Manila many years ago, and was well

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[6] *Agave Mexicana* var. *sisalana*. [7] *Agave Americana*. [8] *Musa textilis*.

known to the older Hawaiians, being used by them in making rope. Also New Zealand hemp [9] has been grown in a limited way.

As a fiber plant Upland cotton,[10] or Sea Island cotton [11] now bids fair to outstrip any of those mentioned. Unfortunately, it has been held in check owing to attacks of the boll worm. Cotton of cultivated varieties was introduced into the islands long ago. A sample of the fiber grown here was sent to China by Kamehameha the Great. The plant in this latitude is a perennial. Several varieties have been experimentally grown from time to time, among them being Sea Island, Georgia, Peruvia and Caravonica, and a number of other strains that have received experimental attention at the hands of Professor F. G. Krauss and his associates. Although the revived industry is hardly beyond the experimental stage, it is reassuring to know that the fiber was an article of export from Hawaii during the Civil War.

The cotton fiber is distinguished from all others by the peculiar twist that it possesses. This twist makes it very valuable in spinning, and it has long been employed in the manufacture of cloth. Its use is spoken of by the earliest writers, and the plant was long described as a natural wonder under the name of the "lamb tree." The cotton of commerce is the product of several species of the genus *Gossypium,* belonging to the order *Malvaceæ,* to which also belong the hollyhock and Hibiscus, the flowers being very much alike. There are fifty or more species of cotton. In fact, one,[12] a shrub with sulphur-colored flowers and having very short, brown fibers about the seed, is found growing in a wild state in the Hawaiian group in dry situations near the sea-shore. It is known to the natives as mao, and can be separated easily from the small tree-like species called kokio,[13] which has brick-red flowers. The cotton plant produces varieties that readily and rapidly adapt themselves to new conditions. Single trees are common in Hawaii that are twenty feet or more in height.

Rubber.

The cultivation of rubber is among the newer industries that promise well in the islands. Several species of rubber-producing plants are well established in various places on the principal islands, and other species are in process of introduction.

One of the oldest, if not the oldest grove of rubber trees, is a small planting of the Ceara species, [14] located at Koloa, on Kauai. It was planted in 1893, and from it a grove was planted at Lihue in 1899. Experimental tapping, under the direction of the Federal Experiment Station, has given a yield of fifteen pounds of rubber per annum from the thirteen-year-old trees, and it is expected that this can be materially increased by proper care, cultivation and improved methods of tapping. The seeds are curious in that they have a thick, hard coating and often require some months for them to germi-

[9] *Phormium tenax.* [10] *Gossypium* sp. [11] *Gossypium Barbadense.* [12] *Gossypium tomentosum.*
[13] *Gossypium drynarioides.* [14] *Manihot Glaziovii.*

PLATE 74. CATTLE RAISING IN HAWAII.

1. Cowboys ready for a round-up on an upland ranch. 2. Herd of white-faced cattle. 3. Rounding out stock for market. 4. Chinese rice-farmer with curious harrow and Water Buffalo. 5. Two Water Buffalo. 6. Loading cattle; the start. 7. Animals being towed out to the steamer. 8. Loading an animal onto the steamer in port where wharfing facilities are not provided.

nate. To hasten germination the seeds are sometimes carefully rasped on either side with a file. The tree is of rapid growth, thriving best in a moist climate. The natural home of the species however, is in the drier regions of Brazil. It is closely related to the Cassava, mentioned elsewhere, and belongs to the spurge family, which also includes the Para [15] and many other rubber-producing plants. The latex or milky sap occurs in the leaves, stems and trunk. There is a continuous network of milk-tubes all through the living green portion of the bark of the tree. The latex is collected by various methods of tapping, and from this gum-like mass the rubber of commerce is refined.

While the earlier plantings were largely of the foregoing species, there is considerable area being planted to Hevea. Both species belong to the *Euphorbiaceæ*. They and their near relatives may be distinguished from other rubber-producing plants by the hard, flinty seeds and the palmate leaves, resembling those of the horse-chestnut. Such latex-producing trees, belonging to the banian family, as the Assam rubber,[16] the pipul tree, or banian fig,[17] are well established.

To the list of introduced species must now be added the Hawaiian rubber tree [18] brought to the attention of the Hawaiian Experiment Station in 1912 for investigation. Its latex-producing characteristics were noted by a chance discovery in the Kona district on Hawaii, where there are several thousand acres of this promising tree. The natives were long familiar with its gum-like latex and gave to the tree the name koko or akoko, in allusion to the milk-sap which exudes freely from the injured bark. The fact that it is a conspicuous tree, often twenty-five feet high, with a trunk ten inches in diameter, and that it occurs in more or less extensive areas on several islands of the group; and, furthermore, that it has long been known to botanists, having been described as a sub-species by Dr. Gray many years ago, indicates how little attention has been given as yet to the investigation of the native flora from the economic standpoint. The tree belongs to the typical tribe [19] of euphorbias in which the flowerhead resembles a single flower. The species has the flowerhead almost sessile and is marked by having small linear leaves with the veins oblique to the rib. So far as its latex-producing qualities have been investigated, the koko seem to give much promise as a rubber-yielding plant. Its discovery points to the wisdom of extensive investigation of this and other economic plants native to the islands, as well as those of promise from other lands that may be suited to Hawaii's soil and climate, with a view to the establishment of economic species in much of the island Territory now given over to cattle ranges, or classed as waste land.

Tobacco.

Climate and soil are thought to have a marked influence on the quality of tobacco,[20] and experiments that have been conducted in the islands in recent

[15] *Hevea Brasiliensis.* [16] *Ficus elastica.* [17] *Ficus religiosa.* [18] *Euphorbia lorifolia.*
[19] *Euphorbieæ.* [20] *Nicotiana Tabacum.*

years, under the direction of Mr. Jared G. Smith, demonstrate that there are extensive areas about the group especially suited to the production of high-grade tobacco. The growing of tobacco, however, is by no means a new thing in the islands; it was early introduced by the whites and grown by the Hawaiians. It received only haphazard cultivation, was improperly cured, and was invariably too strong for commercial use. It was, however, smoked by old Hawaiians to some extent; it being a custom among the natives to take a whiff or two and pass the pipe (made of a root, or a stem or branch) about from one to the other.

The tobacco plant is of American origin, belonging botanically to the tomato and egg-plant family. The earliest voyagers to America found the Indians using the leaves for smoking, chewing, and as snuff; pipes and other means for smoking tobacco have been found buried in prehistoric mounds in the United States, Mexico, and Peru.

Sweet and Irish Potatoes.

Formerly potato[21] growing was an important island industry. In 1849 potatoes stood at the head of the list of exports. The lands best adapted to their growth are in the Kula district of Maui, where they were introduced and planted as early as 1820. Of late years the industry has diminished, owing to unskilled methods of culture and the appearance of various enemies. There are several species and almost innumerable cultural varieties adapted to various soils and conditions that, if introduced, would doubtless extend and revive the industry.

Sweet potatoes[22] were at one time an important field crop. Like the "Irish" potatoes, they were extensively exported during the period of the gold-rush to California. The natives recognized as many as twenty varieties of uala (sweet potato), and several important varieties have been introduced from time to time by Europeans and others. It belongs to the morning-glory family and is easily grown, thriving in loose soils where the rainfall is not too abundant. The sweet potato is usually propagated by cutting off the tops and planting them in a hill of dirt which often is only a pile of loose ash-like soil scraped together.

Cassava and the Castor Bean Plant.

Cassava,[23] though not extensively cultivated, is grown with success in Hawaii. It is an introduced European plant that thrives on all the islands, is free from pests and requires but little cultivation. Its roots produce a useful starch; they are used both as food for man and domestic animals, and in the manufacture of laundry starch. There is a native plant well known to the older Hawaiians as pia, or arrow-root, and in Hawaii, Cassava seems to have fallen heir to this name. Hawaiian arrow-root[24] formerly grew wild,

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[21] *Solanum tuberosum.* [22] *Ipomoea Batatas.* [23] *Manihot utilissima.* [24] *Tacca pinnatifida.*

being most abundant on Kauai. It is quite common throughout Polynesia, growing without care in the native gardens.

The castor bean plant,[25] cultivated in several places, has escaped and grows everywhere as a roadside shrub, often fifteen to thirty feet in height, with a trunk twenty or more inches in diameter. It is a native of western Asia and eastern Africa. The large palmately-lobed, reddish-green leaves and large terminal flower clusters followed by the prickly three-parted burrs, which bear the vari-colored seeds, mark this familiar plant, grown in many gardens on account of its distinct ornamental value. Attempts to grow the castor bean as a field crop have failed only for want of the right kind of labor to gather the crop.

Lotus.

Another plant of considerable importance, both ornamentally and as a crop, is the Chinese lotus.[26] It is a native of China and the East generally, and is grown in Hawaii by the Chinese farmers in taro and rice ponds; often several acres will be seen in a patch. The root tubers, for which it is grown, creep in the mud at the bottom. They are dug at irregular intervals and suggest strings of white sausage, as they are seen in the vegetable stalls. While the tuber is a favorite food of the Orientals, especially the Chinese, Europeans and others seldom taste them, preferring to admire the ornamental effect of the large orbicular leaves and splendid cream-colored, showy flowers that stand high above the water. The seeds are found in an odd-shaped, flat-topped receptacle, and are also esteemed as food by the Orientals.

Nuts.

The curious Chinese horned-nut [27] is also cultivated in shallow ponds by the Chinese, who boil the nuts, much as chestnuts are prepared by the Japanese.

Peanuts,[28] ground-nuts or goober-nuts, as they are variously called, were once grown to some extent, principally for the oil. The crop is well adapted to conditions in Hawaii, as has been proved by recent experiments, and it is to be regretted that they are only grown for the local demand, since, being a member of the great bean family, they store much valuable nitrogen and are therefore beneficial to the soil, besides producing a valuable forage for animals. In competition with the large California nuts, the island-grown product is much finer flavored and are generally preferred in the local market.

The peanut is really not a nut, however. It is a ripened pod with edible seeds, produced by a plant resembling a pea or bean. When the flower falls, the flower stem grows rapidly, curving down into the ground. The peanut is a native of Brazil, where several closely-allied species are found. In cultivation a number of important varieties have been produced, several of which have been experimentally grown in Hawaii.

Among the plants grown especially as green food for animals is sorghum.[29]

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[25] *Ricinus communis.* [26] *Nelumbium speciosum.* [27] *Trapa natans.* [28] *Arachis hypogæa.*
[29] *Andropogon Sorghum.*

It is a grass-like plant, very well suited to the soil, and is regarded as the most profitable crop for forage in the islands. It is grown usually by irrigation and has its greatest use as feed for milch cows.

Forage Grass.

Of the grasses, Bermuda grass, known locally as manienie[30] or creeping grass, has found a permanent place in the islands. The lawns are sodded with it, and it spreads over waste places and affords valuable pasture for stock below the elevation of 800 feet. It was introduced in 1835 by Dr. A. F. Judd. Alfalfa or lucerne[31] is also cultivated to some extent under irrigation, especially by dairymen. It is a native of southwestern Asia, but has long been extensively cultivated in Europe and America. Its purplish-white clover-like flowers and hairy, coiled seed pods will separate it from the true clovers,[32] which are seldom seen in Hawaii. Guinea grass[33] is also cultivated by many dairymen, yielding a number of crops from one seeding, if grown under irrigation, but Para grass[34] is gaining favor more rapidly than any of the strictly forage grasses.

All of the foregoing grasses and a long list of other species were, of course, introduced, coming with commerce or being purposely planted. They supplement a number of native grasses, some of which are of value as food for stock. Among the more important indigenous grasses should be mentioned the native manienie,[35] the kukaepuaa[36] and the pili,[37] which grow generally over the group to 4500 feet elevation. The latter, while very good pasturage for horses and cattle, is not as good for sheep, for, like the piipii,[38] a common grass on open dry plains and slopes, it bears sharp, stiff awns about the seeds that get entangled in the animals' wool.

Most of the foregoing grazing grasses are being rapidly crowded out by the rank-growing, worthless Hilo grass,[39] which is not eaten by animals. It appeared about 1840 in the district of Hilo, having been brought to the islands in some unknown way, presumably from tropical America. The edges of its coarse leaves are rough to the touch, and the stem ends in two slender spikes, three to five inches in length. A closely related species[40] has from three to six alternate spikes and is common in swampy ground in heavy soil. It was used by the Hawaiians to some extent as a thatch. The mischief done by Hilo grass is an example of the damage that may be brought about through the introduction, purposely or otherwise, of undesirable plants or animals.

Weeds.

Space is too limited for an extended list of imported plant pests affecting the farmer and ranchman, but a number of undesirable species have been introduced and have prospered in Hawaii. Among them are the common pur-

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[30] *Cynodon dactylon.* [31] *Medicago sativa.* [32] *Trifolium.* [33] *Panicum maxima.*
[34] *Panicum Molle.* [35] *Stenolaphrum.* [36] *Panicum pruriens.*
[37] *Setropogon = (Andropogon) contortus.* [38] *Chrysopogon aciculatus.* [39] *Paspalum conjugatum.*
[40] *Paspalum orbicularie.*

slane or pussly [41] of our gardens; two species of pepper grass;[42] a sensitive plant [43] with fine leaves and small, round, pinkish flower heads; the flea-bane,[44] the iliohe of the natives; the cocklebur,[45] growing almost perennially and occasionally attaining a diameter of three inches at the ground; the sand burr;[46] the Jamestown weed;[47] the plantain;[48] the wild geranium;[49] and, lastly, and perhaps worst of all from an agricultural point of view, the nut grass, coco grass or Japanese grass—a pest reproducing by nut-like bulbs and by seed, and necessitating the utmost care to eradicate from cultivated fields, lawns and gardens. Among the more common of the related species,[51] often called nut grass, is one that first appeared in Hawaii about the year 1850 and has since spread to all cultivated lands. In this species the tubers of the root-stock have a curious pungent taste.

Livestock.

This account of agriculture would be incomplete without at least a passing reference to the live stock of the islands. All of the domestic animals have been introduced since the first visit of Captain Cook. In many instances live stock has had more to do with bringing about the altered conditions with which the native fauna and flora have had to contend than all the other agricultural pursuits put together, epoch-making as they have been.

The first cattle and sheep were introduced in 1794 by Vancouver and landed at Kealakekua Bay, and in time became wild in the mountains on all the islands. A large proportion of all the meat consumed in the islands is home-grown. Formerly cattle were so abundant that they were slaughtered for their hides and tallow, but that time has long since passed. Horses were first brought to Hawaii in 1803. They were landed at Kawaihae and Lahaina and were the progenitors of the island strain of horses. Pigs and goats of English breeds were first introduced in 1778 by Captain Cook. Turkeys were introduced as early as 1815.

Wild cattle, sheep, hogs and goats were allowed to run at will in the forests, with the result that the animals trampled down the undergrowth and destroyed the bushes, even digging up the roots of many of the more nutritious of the forest growths. Owing to the exposure of their roots and stems, many of the larger trees died and soon after became infested with insects, which in turn multiplied in proportion to the increased supply of their favorite food.

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[41] *Portulaca oleracea.* [42] *Lepidium Virginicum* and *Senebiera didyma.* [43] *Mimosa pudica.*
[44] *Erigeron Canadensis.* [45] *Xanthium strumarium.* [46] *Cenchrus echinatus.* [47] *Datura Stramonium.*
[48] *Plantago major.* [49] *Geranium Carolinianum.*
[50] *Kyllinga monocephala,* a species often confused with several species of the related genera of *Cyperaceæ.*
[51] *Cyperus rotundus.*

END OF BOOK ONE

BOOK TWO

THE ANIMAL LIFE OF THE GROUP

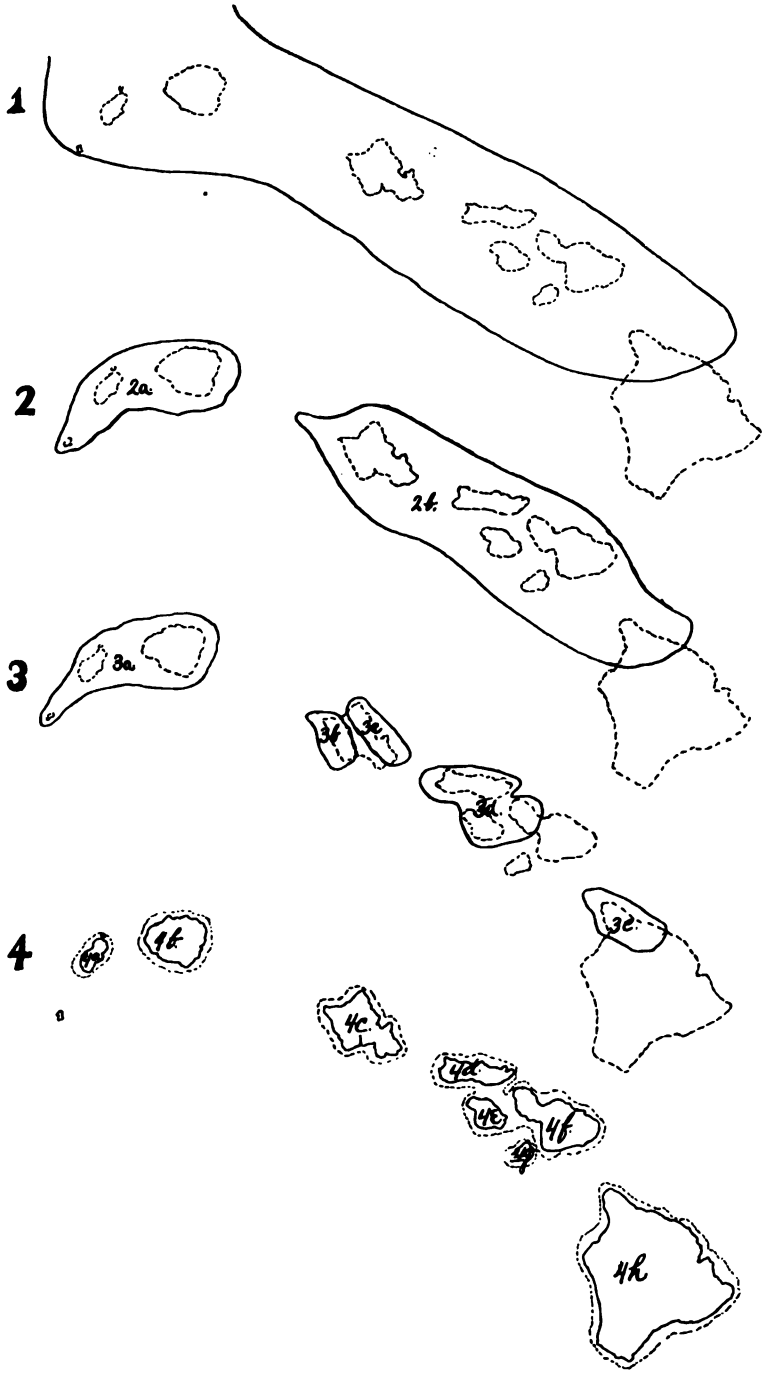

PLATE 75. FOUR STAGES IN THE DEVELOPMENT OF THE HAWAIIAN ARCHIPELAGO (After Pilsbry).

1. Showing the outline of the pan-Hawaiian island. During this stage the group from beyond Kauai to and including the Kohala mountains were united by land. 2. The first

(Description of Plate Continued on the Opposite Page.)

Natural History of Hawaii.

SECTION FIVE

THE ANIMAL LIFE OF THE GROUP.

CHAPTER XXI.

VARIOUS ANIMALS FROM LAND AND SEA.

Hawaiian Rats.

The Hawaiian rat[1] was the largest land animal inhabiting the islands at the time of their discovery by Captain Cook. Unfortunately, the species appears not only to have completely disappeared, but so far as is known not a single specimen has been preserved in any natural history collection or museum.[2] This seems most singular, as we know from Hawaiian tradition that at one time they were very abundant, and for many years were troublesome in cane fields.

From all accounts, they were small in size, and for that reason it is suggested that their place was taken shortly after the discovery of the islands by the common, wide-ranging grey and black rats, as these two species have traveled all over the world in ships and were no doubt passengers on the first ships to touch at the group. It is thought that the early and complete disappearance of the native species may have been due to the aggressive disposition of the new comers, particularly of the brown or Norway species, as wherever this rat has gone—and it is a great traveler—it has gained a footing and, in many places, completely replaced the less pugnacious native forms.

The brown rat[3] is the larger of the two common species in Hawaii at the present time. It is generally believed that this species is a native of Western China, but it was known in England as early as 1730, where it came to be generally, though erroneously, called the Norway rat. It can be at once recognized by its heavy build, massive blunt muzzle, comparatively small ears and

[1] Iole.
[2] Mr. J. F. G. Stokes, of the Bishop Museum, secured bones of what is supposed to have been the Hawaiian rat on Kahoolawe, April. 1913. [3] *Mus demumanus* = *Mus norvegicus*.

(Description of Plate Continued from Opposite Page.)

period of subsidence formed the channel between Kauai (2a) and the Oahu, Molokai, Maui, Lanai, Kohala land (2b). 3. The second marked period of subsidence separated Waianae (3b) and probably Koolau (3c) as islands at one end and Kohala (3e) at the other end of the Molokai, Lanai, Maui area (3d). 4. Shows the last stage of subsidence; the island of Niihau (4a) separated from Kauai (4b); the two islands (3b and 3c) united to form Oahu (4c) and the islands of Molokai (4d), Lanai (4e), Maui (4f) and Kahoolawe (4g) separated by channels less than 100 fathoms deep.

PLATE 76. HAWAIIAN AQUATIC ANIMALS.

Hawaiian Seal (*Monachus schauenslandi*) and Green Turtles [Honu] (*Chelone mydas*) on shore at Laysan Island. Laysan Albatross in the background. Sea Turtles [Honu] thrown on their backs on the sand.

began to escape to a wild life, living on birds and mice in the mountains. Wild cats are particularly troublesome in Hawaii. They are occasionally hunted, especially by sportsmen in pursuit of wild cattle, goats, pigs, chickens and turkeys, all of which, like the cats, have lived many generations in a perfectly wild state in the mountain forests on different islands of the group.

Native Bats.

There seems to have been at least one and perhaps two species of native bats in the islands. They have always been rare, but apparently are still to be seen in the uplands of Hawaii; Dr. R. C. L. Perkins reports having seen the small Hawaiian bat,[11] or opeapea, on both Oahu and Kauai. This bat appears to be the only undisputed natural mammalian immigrant to the group, as the so-called native rat and mouse could have been easily carried to Hawaii in the wreckage of foreign[12] vessels that may have reached the islands by chance long before their discovery by Cook.

Hogs and Dogs.

While it is perfectly proper to say that the rat, bat, and mouse were the only native species of mammalia found by Captain Cook, we can well afford to consider in this connection mammals that were of native introduction—namely, the hog[13] and the dog.[14] Just as the Polynesian people carried useful plants with them on their wanderings, they also brought with them in their canoes these two highly-prized and useful domestic animals known to them in their more ancient home. The hogs[15] varied greatly in color, as they were black, white,[16] brindle, striped, reddish and spotted, indicating that the species had long been in domestication. The Hawaiian dog was fed largely on poi, and was much relished as food in old-time Hawaii. Like the hogs, they were classed according to their color, there being several well-recognized color-types. The Hawaiians also introduced a fowl,[17] which was everywhere a common article of food at the time of Captain Cook's visit.

Introduced Animals.

Since the discovery of the islands a number of mammals and birds have been introduced by accident or design which have been permitted to return to a wild state and in many instances are quite common. The first introduction of this class was that of goats and English pigs, and was made by Captain Cook himself. One ram and two ewes and a pair of pigs were left by him on Niihau in 1788. Cattle and sheep were introduced by Vancouver from California in 1794. They were landed on Hawaii and rapidly increased in number. The first horses in Hawaii arrived in 1803 and were presented to Kamehmeha I.

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[11] *Lasiurus semotus.* [12] Spanish. [13] Puaa. [14] Ilio. [15] *Sus* sp.
[16] The white hogs were often used in making offerings and sacrifices to the gods of ancient Hawaii.
[17] Moa=chicken; moa kane, rooster; moa wahine, hen.

The first deer were brought to Hawaii from Okhotsk, Siberia, in 1856, but the Molokai herd of spotted deer[18] originated from a small flock of eight that were sent to Kamehameha V., from Japan in 1867. They increased in numbers at a remarkable rate; so rapidly, indeed, that they were thought to threaten the destruction of the forests. Some years later the government found it necessary to employ professional hunters to reduce their number; but deer are still plentiful on Molokai, and they furnish the sportsmen of the islands with big game shooting each season.

The ground color of the fur of the spotted deer is rufous-fawn; the whole of the body being marked by a number of spots which are present at all ages of the animals and throughout the year. These spots tend to arrange themselves in longitudinal lines. There is a blackish line running down the back from the nape of the neck to the base of the tail. White prevails on the inside of the ears, the chin, the upper part of the throat, the inside of the legs, as well as the under surface of the tail. A few very large bucks have been shot on Molokai, but the average of the largest would seem to be about 150 pounds, while the does seldom weigh more than half as much.

The spotted or axis deer is a native of India and Ceylon. It is a common species in deer parks everywhere, and has been liberated in several countries in the Orient. They prefer to live in the forests at from three to four thousand feet elevation, where they frequently congregate in small droves, usually in the neighborhood of their drinking places. During the middle of the day they manage to keep out of sight, but as darkness comes on they become active and continue to feed during the night and for some time after sun-up. If disturbed during the day they try to steal quietly away by creeping stealthily off though the undergrowth.

The Mongoose.

The mongoose was first brought from Jamaica, West Indies, in 1883. Thirty-six pairs were imported and liberated on Hawaii in the hope that they would be of value in freeing the cane fields of rats. Unfortunately, they were carried from one island to another before their habits were fully understood, with the result that all of the islands, with the exception of Kauai, are now infested with this animal that has proved to be a pest, about which but little can be said in its favor. The mongoose[19] is a native of India, where the common species is easily tamed. It is yellowish-gray in color, flecked with black, and is mink-like in size and general appearance. Its fondness for poultry and eggs renders it a serious menace to the ranchman. In the back country and the wild mountains it does much damage to ground-nesting birds, and is listed as one among the many causes of the rapid decrease in the number of several of the Hawaiiaian species.

Skinks and Geckos.

Of the land reptiles only seven species of small geckos and skinks have

[18] *Cervus axis.* [19] *Herpestes griseus.*

so far been described from the islands. They are commonly called lizards by Europeans, but were all known by the name moo by the native inhabitants, and were worshipped as gods by the female chiefs. All of the species are quite generally distributed over the group, and, according to my friend Dr. L. Stejneger, who has given the subject much study, the species found in the islands have a wide distribution throughout Polynesia.

They are interesting, harmless little creatures that do much towards keeping mites, ants and mosquitoes in check. For the most part they are nocturnal in habit and are very often seen about houses, on lanais and window screens. During the daytime the common species find shelter in the dark, under boards, in crevices in the bark of trees or any place where they can secrete themselves. Their white eggs are about the size of a small bean, and are usually attached to some object near the place where the mother hides during the day. In due course of time the young animal hatches from the egg and is a miniature of the adult. It is about an inch and a half in length, and at once takes up the task of supplying itself with its natural food. They become quite tame and in many homes are protected and live a sheltered life in a state of semi-domestication.

Of the seven species, four belong to the gecko family.[20] The peculiarities which separate them at once from the skink family are the presence of a large symmetrical shield on the top of the head and the absence of minute scales over the body. All four species of gecko have been taken in the same house, and the characteristics which separate them from one another are somewhat obscure, to the ordinary observer. Those interested in identifying the species should consult Dr. Stejneger's account of the land reptiles of the Hawaiian Islands.

The three species of skinks[21] are small, smooth and shiny, and all have more or less conspicuous longitudinal stripes. They have much the same habits as have already been described for the geckos and, like them, are very liable to lose a portion of their tails at the slightest provocation. The missing portion may be replaced in due time with a new tail which is usually smaller than the portion lost. On rare occasions two or three tails will grow out of the injured stump, giving the animal an odd appearance. The ability of the gecko to change color in order to resemble the object upon which it is resting furnishes an example of voluntary color protection that is most interesting.

Frogs and Toads.

The first frogs were brought to the islands by the Royal Agricultural Society at a date prior to 1867. The earliest definitely recorded shipment, however, was made in the year just mentioned, when "frogs were liberated at Pawaa," in Honolulu. Several species of frogs and toads have been introduced into the group in more recent years, from Japan and America, with the result that they are now common in all the fresh water streams and ponds

[20] *Geckonidæ.* [21] *Scincidæ.*

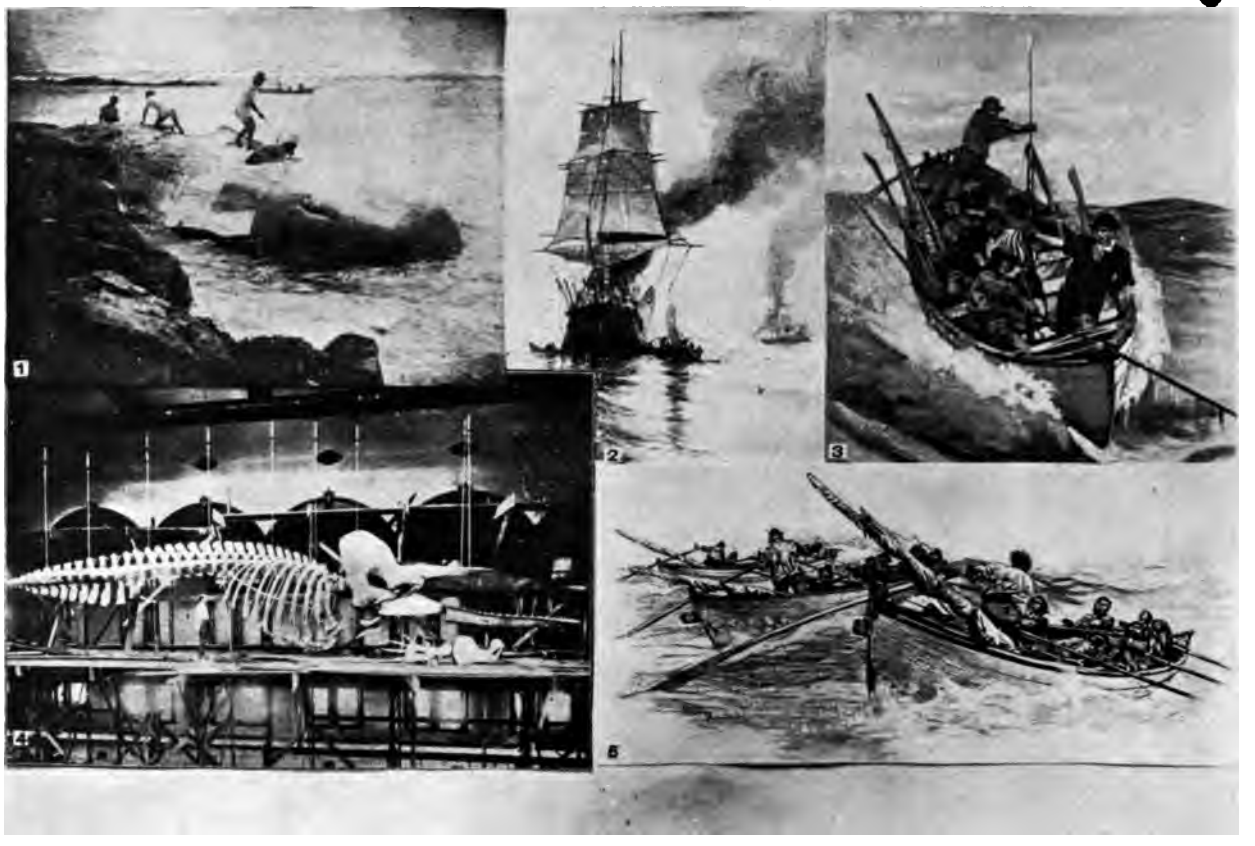

PLATE 77. WHALES AND WHALING SCENES.

1. Sperm Whale stranded on Kauai, October, 1910. 2. Whaleship stripping off "blubber." 3. Whaleboat, fast to a whale. 4. Skeleton of a Sperm Whale in the Bishop Museum (assembled by the author). 5. A race for a whale.

in the Territory. They are of much importance in the ever-present fight against mosquitoes, since they are known to feed on their larvæ. They are also supposed to feed on the liver-fluke which is quite common in certain localities. Bullfrogs [22] of very large size and with very deep bull-like voices are well established, and frogs' legs are often seen in the markets.

Tadpoles of the various species of frogs and toads are plentiful in the pools along the streams far up into the mountains and are sure to attract the attention of the student of nature. A few captured and placed in a jar at home or at school will prove of great interest, as the transformation proceeds from an aquatic fish-like animal with gills, to an air-breathing quadruped with lungs.

No Snakes in Hawaii.

Fortunately, there are no land snakes in Hawaii. On several occasions, however, snakes from California have reached the islands in bailed hay, but as yet they have never made their escape so as to become established here. The same is true of certain California lizards. A specimen fifteen inches in length was killed on the wharf in Honolulu harbor a few years [23] ago. But as commerce from outside ports is safeguarded at present, there is little danger of the larger reptiles gaining a foothold here.

Turning from the land and fresh-water vertebrates to those inhabiting the sea, three specimens of sea-snakes are reported to have been collected in Hawaiian waters. Two specimens, secured on opposite sides of Oahu, are preserved in the Bishop Museum. The first specimen reported, however, was identified by Prof. H. W. Henshaw. It was taken alive at Laupahoehoe, on Hawaii, in 1902, by Mr. E. W. Barnard. When found, the creature was sunning itself on shore and had evidently come from the water to shed its outer skin, which was still attached to the body. The family of sea-snakes [24] to which this species belongs is characterized by having the tail flattened to serve as a fin. The specimen,[25] being the first sea-snake to be taken in Hawaii, made quite a stir at the time, but as it was but two feet in length, and as only three specimens have been reported in the history of the islands, their occurrence here may be considered purely accidental.

Sea-Turtles.

Among the more important animals inhabiting the sea, mention should be made of the two species of sea-turtles that occur in the waters about the islands. They are known as the honu and the e-a by the natives, who are very fond of the honu as a food. In former times the Hawaiians made use of the shell plates in the manufacture of fish hooks, scrapers for removing the trash from olona fiber, and, to some extent, in more recent times, in the manufacture of ornaments. Turtles two feet or more across the shell are not rare, though the specimens which reach the market are usually much smaller. In both species the limbs have become completely modified into flippers or paddles which

[22] *Rana catesbiana.* [23] 1911. [24] *Hydrophidæ.* [25] *Hydrus platurus.*

enable them to swim swiftly in the sea, but render them almost helpless on the land, where if turned on their back, they cannot regain their normal position. They deposit their eggs in the sand in nests which they scoop out to a depth of two feet or more. The most abundant species about Hawaii is the green turtle.[26] It has a strong bill and the center of the back is made up of thirteen plates arranged in three rows, which lie perfectly smooth and never overlap, as they do on the rarer hawksbill turtle [27] or e-a, which furnishes the tortoise-shell of commerce. As its name suggests, this latter species always has a hooked bill. It also has thirteen plates over the back which overlap like shingles on a roof, until it is nearly grown, when they assume the arrangement occurring on the related species.

Galapagos Land-Tortoise.

A specimen of one of the many species of Galapagos land-tortoise [28] is also to be seen in Hawaii. It belongs to the former Queen Liliuokalani, and was brought to the islands by Capt. John Meek between 1812 and 1825. It is reported that at his place on King street he kept "many land-turtles" which were brought home by him on numerous trips to Mexico. When they were finally disposed of the specimen now in possession of her Majesty was given to King Kamehameha III. It eventually passed into the hands of Kapiolani, and after her death was still held in the royal family. It was a large animal when brought to these islands almost one hundred years ago, and without doubt was very old at that time.

A second specimen [29] was kept for a number of years on Nuuanu street in Mrs. Mary E. Foster's wonderful garden of tropical plants. In their native home in the Galapagos Islands, the tortoise feed on cacti and coarse grass, but in captivity they feed on kitchen refuse. While they are dull creatures they are nevertheless objects of great interest and curiosity.

Porpoise and Dolphin.

At least two and probably more species of porpoise [30] occur in the waters about Hawaii. The commoner species [31] is dark gray in color over the back, and is white beneath, varied with small gray spots, and is about six feet in length. The teeth on both jaws are numerous, being about forty in number. The porpoises belong to the great order of aquatic mammals with fish-like bodies [32], which include the true whales and the dolphins, and are known as naia by the Hawaiians. In this order there are no posterior appendages. The anterior appendages act as paddles and are without joints. The tail is horizontally expanded to form a powerful propeller.

The porpoises associate in herds or schools, and their sportive gambols are familiar to almost everyone who has made a sea voyage in the Pacific. As they dive and sport under the bow of a slow-moving vessel they present a sight long to be remembered. At one moment will be seen the roll of the

[26] *Chelone mydas.* [27] *Chelone imbricata.* [28] *Testudo* sp. [29] Died 1908. [30] *Prodelphinus.*
[31] *Prodelphinus attenuatus.* [32] *Cetacea.*

arched back surmounted by the curved fin; at another the white belly will flash in the sunlight as the creature swims along in a series of graceful curves in the surface water. Not infrequently scores of them will be seen swimming and leaping about a vessel for hours together. It is then that the voyager is often given his first opportunity to see a harpoon thrown from the bow of the vessel. Perhaps if a successful thrust is made, one of these odd mammals will be brought on deck, where it can be examined at close range.

The term dolphin is rather loosely used and is sometimes applied to a fish, sometimes to a narwhale, but more often to the grampus or killer. The name properly belongs to a genus of animals world-wide in their distribution, of which the common dolphin,[33] a species that abounds in all temperate and tropical seas, may be considered as typical. But as there are several closely-related species, it is difficult to identify them in the water or to separate them from the porpoises without specimens and recourse to extended technical descriptions.

Whales.

It should be stated in this connection that the waters of the Pacific are inhabited by several species of whales, of which the right whale or whalebone whales,[34] with three or more wide-ranging species, are the most important. However, the sperm-whale or cachlot[35] and the humpback[36] are perhaps the most common. In times past the pursuit of whales and the whaling industry was a matter of great commercial importance to the Hawaiian Islands.

Although by their mode of life they are far removed from observation, whales are in many respects the most interesting of all creatures, and there is much in their habits worthy of study. The whalebone, or Arctic right whale[37], attains, when full grown, a length of from forty-five to fifty feet. The head is enormous in size, exceeding one-third the length of the creature. The upper jaw resembles nothing so much as a large spoon. The whalebone blades acquire a length of ten or twelve feet; there being about 380 on each side of the upper jaw. These blades are black in color, fine and elastic in texture, and fray out on their inner edges and ends into soft, delicate hairs. The remarkable development of the mouth and of the various structures connected with it bear a close relation to the food habits of this whale. By means of the seine or seive-like apparatus just described, it is possible for these animals to capture the minute forms of life which swarm in immense numbers in the seas it frequents. The elastic whalebone of commerce has long been a valuable commodity, and many a fortune has been made from the whaling business. In recent years, owing to the decrease in the number of whales, the price of whalebone has been as high as twelve thousand dollars per ton.

The sperm-whale, or palaoa of the natives, is the largest representative of the toothed whales, and in length and bulk it somewhat exceeds that of the

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[33] *Delphinus delphis.* [34] *Balæna* spp. [35] *Physeter macrocephalus.* [36] *Megaptera* sp.
[37] *Balæna mysticetus.*

right whale just mentioned. The head differs from that of the right whale in being over one-third the length of the body, very massive and high, and is abruptly truncated in front. This curious development of the head is mainly caused by the bulk of fatty tissue massed in the large hollow on the upper surface of the skull. The weight of the skull is very great. The skeleton of the specimen assembled by the writer, now on exhibition in the Bishop Museum, weighs almost three thousand pounds.

The blow-hole is placed on the anterior extremity of the head a little to one side of the center. Owing to the curious shape of the head in the sperm-whale, the "hump," when the animal comes to the surface to blow, is in front of the spray; in the right whale and the humpback, the hump is behind the spray. Owing to this difference the experienced whaler is able to identify the species miles away from his ship.

The lower jaw of the sperm-whale differs from that of the right whale in being narrow and in having from twenty to twenty-five stout conical teeth six or eight inches in length, that are composed of ivory of good quality. Whale ivory was much prized by the native Hawaiians, and used by them in the manufacture of the jewelry and ornaments of which mention has already been made.

The sperm-whale is doubtless one of the most widely distributed of living animals, being met with usually in herds or schools in almost all tropical and sub-tropical seas. Its food consists mainly of squid and cuttlefish, but the larger fish are also devoured, though how they are captured yet remains a mystery. The substance known as "ambergris," formerly used in cookery and medicine and now in the manufacture of perfumery, is a concretion formed in the intestines of this and perhaps in other species of whales, and is occasionally found floating on the surface of the sea or cast up on the open beach.

The right whale is pursued primarily for its whalebone, though its blubber is a valuable by-product. The sperm-whale is sought for chiefly for the large quantity of whale oil which it yields. This oil varies in color from a bright honey-yellow to a dark brown, according to the part of the animal from which it is taken. The best oil is that taken from the head, where it occurs as pure oil and may be dipped out with a bucket. Sixty to eighty barrels of oil from the head alone were not uncommon records when whaling was at its height.

The humpback whale,[38] or kohola of the Hawaiian seamen, is a large species and belongs to the group characterized by the presence of a number of longitudinal flutings or folds in the skin of the throat, and by the fin on the back. They were formerly quite common off the Island of Maui during the winter season, and were occasionally captured and brought to land. In more recent times, while both humpback and sperm-whales are seen quite frequently each year about the islands, but little attention is paid to them unless they chance to become stranded, as occasionally happens. In ancient times all whales and porpoises[39] cast ashore were the property of the alii, or chiefs, and the wearing of whale-ivory ornaments was limited to that class.

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[38] *Megaptera hoops.* [39] Naia.

The Whaling Industry.

In the old whaling days vessels engaged in the trade ranged up to four hundred tons burden, and were often outfitted for a two or three years' voyage. Their usual destination being the "south seas," they frequently utilized Hawaii as a depot station. A whaling vessel usually carried six whaleboats. These were about twenty-seven feet in length, with four-foot beam, and were pointed at both ends.

When a whale was sighted, four boats put off at once, each being provided with a pair of two-hundred-fathom harpoon lines and carrying a crew of six men. "It was the business of the boat-steerer to harpoon the whale when it came to the surface to spout. When this was done he changed places with a member of the crew, whose duty was to kill the animal with a lance. When a whale was harpooned, immediately after the first struggle and when it was lying exhausted from its endeavors to escape, the boat was pulled close alongside, and the headsman began the work of destruction by thrusting his lance into the vital parts behind the flipper. As soon as the whale was lanced the boats were backed with all possible speed. When first struck the whale frequently 'sounded' or descended to immense depths, sometimes taking out nearly all of the eight hundred fathoms of line carried by the four boats. Subsequently, however, when weakened by the loss of blood, it kept on or near the surface, towing after it one or more of the boats. By hauling in the line the boat or boats were pulled up alongside and the monster finally destroyed, either by darting or thrusting with the lance."

Whaling as thus carried on was full of dangers, and an occupation calculated to be followed only by the most hardy and venturesome; hundreds of accounts of hairbreadth escapes from death have been chronicled in the pursuit of this business in which, at its height in 1852, no fewer than two hundred and seventy-five American vessel were engaged, in the north Pacific alone. The amount of oil taken that year by the fleet exceeded 337,000 barrels, and more than 5,000,000 pounds of whalebone was secured.

The Hawaiian Islands were in the center of this trade, and thousands of the native Hawaiians were employed as whalers. The business developed in the ports of the islands furnished the impetus and the foundation for more substantial and diversified trade that has rapidly increased in volume to the present, though whaling, on anything like an extensive scale, was practically at an end by 1875.

As long ago as 1824 the brig Ainoa set out from the islands for a sealing voyage. At different times, but particularly in 1859, sealing expeditions have been made among the islands to the west of Kauai. In that year the Gambia returned to Honloulu with fifteen hundred skins and two hundred and forty barrels of seal oil. This furnishes us with a record of the former abundance of the seal [40] in the Hawaiian group. Of recent years they have been far from

[40] *Monachus schauinslandi.*

abundant, though seals are regularly reported from Laysan, Lisiansky, Pearl and Hermes Reef, and are occasionally seen at Midway. In January, 1912, the U. S. Revenue cutter Thetis returned from a cruise to Midway and Laysan and brought a seal-skin back which was presented to the Bishop Museum. Baby seals were seen at that time, and it is quite probable that, if not interfered with, the herd will increase in numbers.

CHAPTER XXII.

INTRODUCED BIRDS.

The nature-lover visiting Hawaii for the first time is sure to be disappointed by the limited number of species of birds to be seen in Honolulu and along the main traveled roads about the islands. Were it not for the presence of the dozen or more species of birds that have been introduced into Hawaii by accident or design, it is doubtful if the average tourist would see or hear a single bird during his stay in the group. It is unfortunate that of the one hundred and twenty-five or more species enumerated in the list of birds in the islands, not more than half a dozen will be seen within the city of Honolulu, and all of these are introduced from other lands.

The English Sparrow.

The English sparrow[1] is perhaps the most abundant bird about the city. This pert, saucy and industrious Britisher is six inches or so in length, and has a brownish back, streaked with black. In the adult male the conspicuous black throat patch makes it a species easily recognized as an old acquaintance of a distant land, and serves to distinguish it from the house finch or the "rice bird,"[2] the only other species with which it can be confused. The latter species is about the size of its English cousin, but is light ashy-brown, streaked with dark brown above. During the mating season the male has the throat and breast a crimson color. The English sparrow's eggs are always spotted, while the house finch's eggs are smaller and are a very pale bluish tint.

Rice Birds.

There is also another rice bird, much smaller than the California house finch. It is usually seen flying in small, compact flocks. In reality it is a weaver bird and belongs to a different family from that of the two species just described. Doubtless it arrived in Hawaii many years ago as a cage bird that came originally from the Malay Peninsula. As so often happens with pets, it probably escaped from captivity and has since become common throughout the group. While it is called a rice bird, it is better known locally as the Chinese sparrow.[3] It is about two-thirds the size of the larger rice bird, and

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[1] *Passer domesticus.* [2] *Carpodacus mexicanus obscurcus.* [3] *Munia nisoria.*

in general color is a warm chocolate brown. When a specimen is in hand it will be found that each feather over the back is marked by a narrow white shaft line. All three of these sparrow-like birds feed at certain seasons on the cultivated rice—a fact that has produced much confusion in the popular mind as to just which species is in reality entitled to be called the rice bird.

The combined damage that these birds do to the growing grain from the time the kernels of rice begin to form in the heads until the crop is finally harvested, amounts to many thousands of dollars annually. The rice farmers patrol their fields during this season, from early morning until sundown, discharging "rice guns," shouting and conducting a general crusade against the birds. Many Chinese farmers set up scarecrows, to which windmills and noise-making devices are attached, to guard the ripening crop. Others will ingeniously run stout wire supported above the grain on bamboo poles, over an entire field of grain. From these dangle a motley array of old tin cans, clappers and other noise-producing junk. The free ends of all of the main wires center at a conveniently-placed elevated platform from which the farmer keeps a sharp lookout for the feathered despoilers of his harvest. Just as the flock alights on the drooping heads of grain, the farmer pulls the main wire that runs to the place under attack. The neighborhood resounds with the din, with the result that the intruders fly to some other spot, where the same form of repulse is resorted to. In a short time the birds find that they are more scared than hurt by the noise, and become more and more bold, often standing their ground without wavering through the veritable pandemonium. The writer has watched with much interest the development of courage among these uninvited and unwelcome bird guests, and doubts whether much is gained in the long run by this form of warfare, save the satisfaction to the farmer of doing something to protect his crop.

Chinese Turtle-Dove.

The Chinese turtle-dove,[4] as its name suggests, came originally from China. It is another introduced bird that is abundant in the rice fields, more especially after the crop has been gathered. They then visit the fields in pairs or in small flocks to glean the scattered grain that may be left after the frugal Chinese farmers' wives have gathered in the last straws left lying on the ground by the harvest-men.

Dove shooting is said to be real sport in Hawaii, and those who indulge in it as such are always anxious for the open season to begin. An expert marksman, in the height of the season, will secure a bag of fifty or sixty birds in a single day. Though the dove is modest and retiring, its mournful call is not an uncommon sound in the city; the flat, loosely-constructed nest in which two white eggs are laid, is occasionally found in the trees and shrubs forming the tropical tangle that often surrounds the Hawaiian home.

[4] *Turtur (Spilopelia) chinensis.*

The Mynah Bird.

No bird in Hawaii is more conspicuous or more thoroughly at home in his adopted land than is the false mynah[5] or mina. The mynah was brought to Hawaii by Dr. Wm. Hillebrand years ago to feed on the cutworm of a certain moth.[6] The birds flourished and multiplied and have had an important part in the reduction of the pest. Although not without bad habits, they must be regarded as generally beneficial in their food habits.

Had they not become fond of the seeds of the introduced lantana—and thus become directly responsible for its being spread broadcast over the islands—there is little doubt but that the mynah would have been generally held in higher esteem than it is today. Their size, industry and sociability make them interesting objects wherever they are, and the study of their nests, food, and life habits will well repay the observing bird-lover.

The false mynah is so called to distinguish it from the true mynah of India, a bird which they resemble in size, habit and general characteristics. It is an exceedingly sagacious bird, and readily learns new tricks that enable it to adapt itself to peculiar and unusual conditions of life. There are cases on record where the young have been taught to say single words; but in linguistic attainments they are not the equal of their Indian cousins.

Their nests, which are built in odd places about buildings, under rafters, in eaves-troughs, or occasionally saddled into forks of trees, are invariably bulky affairs. Their eggs are of fair size and blue in color, resembling those of the American robin. All day long they scold, call or try to sing as fancy strikes them, but at night, as they congregate in certain large banian trees about the city in flocks of hundreds, the noise they make in taking leave of each other and of the day, before going to roost, is little short of deafening. The first faint glow in the east is the signal for them to take up the argument and the work where they left off the day before. So day after day the unmusical voice of the mynah, as it dins its call into the ears of the traveler, morning, noon and night, comes to be the sound from Hawaii that lives longest in the memory. Likely as not, years afterward, when the sight of old Diamond Head and her waving cocoanut palms and the languid caress of the soft air of the tropics are but shadowy memories, it will be some harsh bird-note, caught by the listless senses in an idle moment, that will again vividly bring to the mind of the traveler the mynah, and its noisy evening song, and the twilight scene it revives in fancy.

There is a popular though erroneous belief in Hawaii that the mynah is responsible for the disappearance of the native birds. The fact that this noisy stranger is frequently found in the forests at an elevation of five or six thousand feet, is offered as an explanation for the singular passing from the forest regions of many species of native birds. There is little reason,

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[5] *Acridotheres tristis.* [6] *Spodoptera mauritia.*

however, for supposing this to be the true cause. There may be cases, about settlements especially, where the mynah has been known to interfere with the nests and eggs of certain birds, particularly those of the English sparrow, a species with which its habits bring it in sharp and direct contact; but so far as the opinions of the best observers and my own experience go, the mynah, when he finds himself in the forest, lives at peace with the native birds. The general habits of the forest birds differ widely from those of the mynah, and their nesting and food habits are so different that the two seldom come into conflict.

The Skylarks.

The English skylark[7] was introduced into Hawaii purely for sentimental reasons, because of its beautiful song. Many persons who have settled in Hawaii came directly from England, and were familiar with the profuse strains of this songster in their native land; naturally, the lark is a favorite with them. These birds, now fairly common in the pastures and on the open forehills of the principal islands of the group, are descended from birds brought by the Hon. A. S. Cleghorn from New Zealand, where the bird had been successfully introduced from England by early colonists.

The lark is a dull-brownish bird, well known to every one who strolls along the paths that lead into the mountains. Often they will be startled into song from the roadside by the rumble of a carriage or the tread of a pedestrian, and, singing, they will mount higher and higher into the sky, carrying their song with them, up, up, until both singer and song are lost to sight and ear. They are not content with merely lilting their song to the heavens, but will sweetly and skilfully coax it back with them to earth again. It often happens that a half dozen of these blithe singers will mount skyward at the same time, dropping after them a veritable shower of song that could but delight the most careless cross-country rambler, and bring him home again glad that there is in Hawaii such a bird as the skylark.

Pheasants.

The several species of game-birds that have been introduced into Hawaii are of special interest to the sportsman. To the credit of many of our foremost citizens of a generation or more ago, pheasants and quails were brought to Hawaii at private expense and liberated. New breeding stock has been brought in, from time to time, and the welfare of the game-birds so guarded by law that they have increased, particularly on the islands of Kauai and Molokai, until they are sufficiently abundant to make game shooting an enjoyable sport.

Two species of pheasant are now well naturalized in Hawaii. The ringneck or Chinese pheasant[8] came originally from China, but as it has been extensively reared in England and America, usually as a cage-bird, it is dif-

[7] *Alauda arvensis.* [8] *Phasianus torquatus.*

ficult to tell from whence the Hawaiian stock was derived. The back of the male is a fine coppery-chestnut color, the neck a beautiful metallic-green, with a narrow white collar about the middle, and the breast a gorgeous metallic-copper color with purple reflections.

The Japanese pheasant[9] is about the same size as the Chinese species. The pure-blooded male can be easily identified, as its underparts are dark green and there is no white ring about the neck. The females of the two species are more difficult to identify, especially in Hawaii, where hybrids between the two species frequently occur that rival the pure stock in size and beauty of plumage.

The California Partridge.

The California partridge[10] is well established in the islands, especially on Hawaii, Maui and Molokai. The pretty black crest and throat and black scale-like markings on the belly, with a central patch of chestnut on the breast of the males, and the prevailing smoky or brownish color of the females, taken together with the habit, size and rapid flight of the partridge, makes it an easy bird to recognize, as they scurry across the road or take flight from under foot and whir through the air like so many winged bullets.

The pheasants and partridges prefer the open country, the forehills, and straggling scrub about the lower edges of the mountain forests, and in spite of the damage to them and their nests that is directly traceable to the mongoose, they are generally believed to be increasing in numbers.

The wild fowl, or moa, was introduced by the natives long before the coming of the white man, but since his coming other breeds have escaped into the mountains and a mongrel Hawaiian wild chicken has resulted. The introduction and liberation of certain domestic birds, as turkeys, pea-fowls, guinea-fowls and the like, have been made from time to time until they are quite common in a wild state on the different islands.

Other birds have escaped and become established, among them a parrot on Maui and a Chinese thrush[11] on Oahu; though the latter is not a thrush, but a reed-warbler. It is to be hoped that ere long the scientific introduction of desirable economic species will be undertaken, since there are many species of birds in America and elsewhere that, if brought to Hawaii, would fill a useful place in the economy of nature, and at the same time add by their presence to the pleasure of life in both city and country.

CHAPTER XXIII.

BIRDS OF THE SEA AND OCEANIC ISLANDS.

Regular Visitors and Ocean Waifs.

Of the little list of less than thirty species of sea-birds of which Hawaii can boast, almost half the number are very rare winter visitors. As a rule

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[9] *Phasianus versicolor.* [10] *Lophortyx californica.* [11] *Trochalopterum canorum.*

these are ocean waifs—young and unexperienced birds—that have lost their way in an attempt to migrate for the first time along the American coast on their way to their winter homes in the South. Such birds are rare in the islands and are seldom seen outside of museums. They are usually, though not always, common west coast species of gulls and terns[1] and ducks.[2] Birds of these families are well adapted by nature to enjoy life on the island shores and reefs, and one is led to wonder why some of them, in times past, have not taken up a residence and settled down to a fishing life, and become abundant along Hawaii's coasts, now sadly destitute of sea-bird inhabitants.

Unfortunately for the bird student, only a few of the species that regularly frequent the waters about the islands ever come close enough to the shore to be identified more exactly than to say that they are large or small sea birds. Of the limited list that may be said to be common about the group, there are as many as four species that nest in holes which they find or make in the faces of the high cliffs in the mountains in the large inhabited islands. They may be seen occasionally in the daytime flying over the land, but generally only their curious calls can be heard, as they are nocturnal in habit and are seldom abroad during the day.

Tropic Birds.

The white-tailed tropic bird[3] is the species most commonly seen during the daytime. It is a beautiful white bird, and in fine weather, in favored localities, as many as half a dozen may be seen at once, gracefully floating about the cliffs at the head of the principal valleys of the islands. They lay but a single large, cream-colored egg—thickly blotted, splotched and mottled with rich brown—which they deposit in a nest of loose straws, tucked in a crevice in the face of the cliff. The young nestling differs from the adult in that the body and head are mottled black and white. In this stage they resemble the young of the red-tailed species[4] which occurs on the low sand islands of the northwest chain. The adults differ from the red-tailed species, as their name suggests, in having their long tail white, or salmon color, instead of deep red. The plumage of both species was much used in Hawaii in times past in the manufacture of the native kahilis that are elsewhere described. The birds were also used as food by the natives.

Petrels and Shearwaters.

The Hawaiian petrel,[5] Newell's shearwater,[6] and the Hawaiian stormy petrel[7] are all small or medium-sized, dark-colored sea-birds with hooked bills; they nest in holes in the mountains. Although they and their habits were well known to the Hawaiians, who were expert naturalists, they have continued to be very rare specimens in collections, owing to their night-flying habits and the almost inaccessible places in which they nest. They were a

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[1] *Laridæ.* [2] *Anatidæ.* [3] *Phaethon lepturus.* [4] *Phaethon rubricauda.*
[5] *Estrelata sandwichensis.* [6] *Puffinus newelli.* [7] *Oceanodroma cryptoleucura.*

PLATE 78. GROUPS OF HAWAIIAN BIRDS IN THE BISHOP MUSEUM.
(Collected and mounted by the Author.)
(For Description of Plate See Opposite Page.)

favorite food in the old days, much resembling squab in flavor, and were preferred on the Hawaiian table over the tropic bird, whose flesh had a strong fishy flavor. These species all lay but a single dull-white egg. Without doubt all four of the cliff-nesting species mentioned above are doomed to extinction in the islands, owing to the inroads made upon them by the mongoose, which is a serious menace to all ground-nesting birds.

Perhaps the average person sees more birds from the deck of an island steamer than in any other way. In fact, most of the more common day-flying, sea-going species may be identified by a practised observer while crossing the channels between the islands.

Terns.

The small, graceful black bird with a silvery-gray crown, flying usually in small flocks, is almost sure to be the Hawaiian tern,[8] although it is easily confused with its cousin, the noddy tern,[9] from which it differs chiefly in being a trifle smaller and of a more slender build.

Both species are active fishers, capturing their prey by flying close to the surface of the ocean and swooping down upon any of the small, unwary species of fish that abound in the surface water five or ten miles off the coast. Both of these graceful birds have much the same habits and disposition. The writer has taken the nests and eggs of both species from crevices in steep sea-cliffs as well as from the tops of low bushes growing on the flat sand islands of the group. Both birds were formerly used to some extent as food. They were usually captured by the natives at night by the aid of torches. The light served to bewilder the birds, causing them to fly, aimlessly about, when it was an easy matter to knock them down with sticks and poles.

Like many sea-birds, both species lay but a single egg, which they place on a small heap of sticks and seaweed that serves as a nest. The eggs are

[8] *Micranous hawaiiensis.* [9] *Anous stolidus.*

Description of Plate.

1. View of birdlife on Laysan (opposite side of the group shown in fig. 7). In the burrow, Bonin Petrel (*Æstrelata hypoleuca*); under the bushes a Red-tailed Tropic Bird (*Phaethon rubricauda*); on the bushes two Noddy Terns (*Anous stolidus*) and an old and young Hawaiian Tern [Noio] (*Micranous hawaiiensis*); on the rock and bushes a Red-footed Booby (*Sula piscator*); on the rocks two old and young White Terns (*Gygis alba kittlitzi*); on the sand one Christmas Island Shearwater (*Puffinus nativitatis*). 2. Pair of Man-o-'war Birds [Iwa] (*Fregata aquila*) on the nest showing the large red gular pouch on the male. 3. Group showing old, young, immature and egg of the Black-crowned Night Heron [Aukuu kohili] (*Nycticorax nycticorax nævius*). 4. Black-footed Albatross (*Diomedea nigripes*). 5. Group of Hawaiian shore-birds; five Turnstones [Akekeke] (*Arenaria interpres*) are shown in the act of lighting; on the rock a Bristle-thighed Curlew [Kioea] (*Numenius tahitiensis*); to the left Hawaiian Stilt [Kukuluaeo] (*Himantopus knudseni*); by the water's edge Pacific Golden Plover [Kolea] (*Charadrius dominicus fulvus*); one just rising and one preening Wandering Tatler [Ulili] (*Heteractitis incanus*). 6. The Hawaiian Goose [Nene] (*Nesochen sandvicensis*). 7. Opposite side of fig. 1, Birds in flight Sooty Tern (*Sterna fuliginosa*); on the bushes Red-footed Booby (*Sula piscator*); on the ground left Blue-faced Booby (*Sula cyanops*); on the ground in center Grey-backed Tern (*Sterna lunata*); in the deeper hole Bulwers Petrel (*Bulweria bulweria bulweri*); in the shallow burrow Wedge-tailed Shearwater (*Priofinus cuneatus*) old and young.

even more alike if possible than the birds, and a description of one will suffice for both. They are usually a little smaller than a bantam chicken egg, and clear grayish-white, variously splotched and mottled with clove-brown, varied often with lilac markings.

The sooty tern[10] is a beautiful, graceful species common in the waters about the islands. It may be identified by its typical tern-like flight and the fact that the upper parts are sooty-black while the under parts, forehead and a narrow stripe over the eye, are white.

Two or three species of small, tube-nosed swimmers that skim singly, or in pairs, over the water, that all pass in the distance as "mutton birds," are as liable to be one as the other of the wedge-tailed shearwater,[11] the Christmas Island shearwater,[12] the Bonin petrel,[13] or the Hawaiian petrel.[14]

Where careful identification is possible they may prove to be something very different, however, and it is unsafe to hazard more than a guess as to the name of a species seen on the wing at sea. Fortunately, there is no ground for uncertainty in the identification of the large, tube-nose swimmers.

Albatross.

The black-footed albatross[15] is sooty-brown all over, while the Laysan Island albatross[16] has the abdomen white. Both species are about the size of a large goose and are called gooneys by the sailors. They both follow vessels crossing the Pacific, for hundreds of miles on their journeys to and from the islands. Not infrequently a flock of three or four birds will follow a steamer for days, eagerly seizing the bits of waste that may be thrown overboard from the cooks' galley.

Man-o'-War Bird.

The majestic black man-o'-war[17] bird, often little more than a mere speck in the clear blue sky, is easily recognized as it sails high overhead, circling round and round for hours at a time without the slightest apparent effort; they are objects of never-failing interest, serving often as a welcome diversion to relieve the monotonous round of daily life on board an ocean liner in the tropics.

Interesting as the Hawaiian species of sea-birds may be when on the wing, their home life is a great deal more so, and fortunate indeed is the person who is able to spend a few days in one of the large colonies to be found on all of the smaller uninhabited islands that lie to the northwest of Kauai.

Birds of Laysan Island.

Laysan is perhaps the largest sea-bird colony in the tropics, and its teeming hordes of bird inhabitants may justly claim for it a place as one of the great natural wonders of the world. The island itself is scarcely two and a

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[10] *Sterna fuliginosa.* [11] *Priofinus cuneatus.* [12] *Puffinus nativitatis.* [13] *Estrelata hypoleuca.*
[14] *Estrelata sandwichensis.* [15] *Diomedea nigripes.* [16] *Diomedea immutabilis.* [17] *Fregata aquila.*

half miles long by one and a half broad, and is about forty feet above the sea at the highest point. In form, it resembles a great oval platter, and dish-like, it holds a shallow salt-water lake that varies in size to correspond with the amount of rain that falls on the island. There seems to be abundant geologic evidence to prove that the island was at one time a closed coral reef or an atoll that in the remote past was elevated above the surface of the sea. Thus, the coral stone foundation was formed around the salt lake that the sea and the wind have since made over into a sand island.

The low sand rim that surrounds the lake and forms the island proper, slopes gently toward the sea without, and the lake within. On this double beach that is half or three-quarters of a mile in width, a few varieties of hardy beach plants have established themselves. Besides helping to hold the sand in place with their roots, these plants have added the last touch necessary to form an ideal home for this monster bird colony.

This sand ring in the midst of the ocean is the regular home of more than twenty species of birds, five of which are found nowhere else in the world. I have estimated from personal observation and data gathered for the purpose that more than ten million birds formerly visited Laysan Island each year. In addition to the rather large list of regular residents that form the bulk of the inhabitants, the island has a goodly number of species that visit it each winter, including such birds as tattler, plover, curlew, turnstone, canvas-back, shoveler, and a dozen or more occasional or accidental wanderers, making a total of at least three dozen species of birds that are known to visit this mere speck of dry sand.

Naturally, the struggle for existence, often for mere nest-room, is intense. The air, the vegetation, the earth—all literally swarm with bird life. Almost every inch of land down to the water's edge is occupied. In their home life this concourse may be likened to the inhabitants of a great city. Not finding room enough for all to live on the ground, they have turned the island into a great apartment house, several flats in height. Nor are all the flats above ground. Some of the petrels, for example, dig holes five or six feet deep and in them live thousands and thousands of night-flying birds that rear their young, as it were, in the deeper sub-basement of the colony. Another species digs but two or three feet deep in the sand, and in this way occupies the entire sub-basement flat, without fear of molestation by the neighbors, above or below.

The basement is inhabited by the wedge-tailed shearwater. It has chosen this part of the island as a home, and the burrows that they make are in countless thousands and of such size that a person walking across the island must be careful where he steps, lest in an unguarded moment he caves in the roof of a burrow and drops hip-deep into it.

The surface of the ground, to continue our comparison, is the most valuable and hence the most densely-populated part of this wonderful bird city. Under the bushes, in the roots of the grass, in the open spaces about the bunch-grass, along the shore of the lake, or on the sea slope, a dozen species find the

conditions, conveniences and location that appeal most to their fancy, and they occupy the site selected by the colony to its fullest capacity. In the bunch-grass the little flightless rail[18] is found, nesting among the thick stems close down to the ground. The miller bird[19] and the Laysan canary[20] nest in the main stems of the bushes, and next above them the tastefully arranged nests of the Laysan honey-eater[21] is placed. On the tops of the bushes, occupying the choice top-flats, terns, boobies and man-o'-war birds contend among themselves and with their neighbors for the desirable locations; while overhead the air is literally filled with swarms of birds.

Laysan is a veritable bird-lovers' paradise, for, having no knowledge of man, most of the species are without fear and may be lifted from the nest with the hands like a setting barnyard fowl.

The Albatross Dance.

By reason of their number, size and unusual personalities, there are no more interesting birds in the colony than the two species of albatross to which allusion has already been made. The Laysan or white-breasted species are most abundant and are widely distributed over the island. From the middle of October, when they begin to reach the colony—returning from, nobody knows where—all through the winter months and until the young are ready to leave with their parents the following July, the island is covered with albatross. Looking in any direction, one can see the old birds standing stolidly about, sitting on their nests, or engaged in their curious dance—a singular performance for which the albatross is justly famed.

This game, or dance, or cake-walk, or whatever one may care to call it, is more than a form of courtship, since it is indulged in at all times, day or night, during the entire period of the birds' long stay on the island. It is without exception the most amusing performance I have ever seen birds indulge in. The dance is so aptly described by Dr. W. K. Fisher, that I quote from his account:

"Two albatrosses approach each other, bowing profoundly and stepping rather heavily. They circle around each other, nodding solemnly all the time. Next they fence a little, crossing bills and whetting them together, pecking meanwhile and dropping stiff little bows. Suddenly one lifts its closed wings and nibbles the feathers underneath or, rarely, if in a hurry merely turns its head, and tucks its bill under its wing. The other bird during this performance assumes a statuesque pose and either looks mechanically from side to side or snaps its bill loudly a few times. Then the first bird bows once again, pointing its head and beak straight up, and utters a prolonged nasal groan, the other bird snapping its bill loudly and rapidly at the same time. Sometimes both birds raise their heads in the air and either one or both utters the indescribable and ridiculous bovine groan. When they have finished they begin bowing to each other, almost always rapidly and alternately,

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[18] *Prozanula palmeri.* [19] *Acrocephalus familiaris.* [20] *Telespiza cantans.* [21] *Himatione freethi.*

and presently repeat the performance, the birds reversing the role in the game or not."

Many variations occur in the order of the dance. Sometimes three or more birds will become involved, which adds to the ludicrous nature of the performance, as it becomes at once evident that the birds are unable to dance the more complicated round dances and attempts to do so almost invariably result in a breakdown before the dance is carried to the squawking stage. By way of variety, one of the birds will sometimes pick up a feather or stick and tender it to its partner, who promptly returns the compliment, when they pass to the next form, and so on. Through varying figures and manœuvers these birds will continue their play, often for ten or fifteen minutes without cessation. When the end comes, however, it usually follows the uttering of a prodigious groan, after which the birds retire to a respectful distance from each other and resume their ordinary vocation of preening, sunning themselves or merely looking on while their neighbors amuse themselves in the same form of play. So common is the "dance" among them that dozens of couples may be seen engaged in it at any hour of the day or night.

While the albatross rears a family of but one, they devote much time to the feeding and care of their offspring. The downy nestling issues from a large, dirty white egg (as large as that of a goose) that may be heavily blotched with brownish-maroon, which encircles the egg in a band; or from a brownish-buff egg, without any markings whatsoever. However varied the color of the egg may be, the young birds look so much alike that it is impossible to tell how they are recognized by their parents. Fortunately, there seems to be little difficulty, and the old birds seldom molest one another or their neighbors' children.

The old birds seem to be very active at night and apparently do a great part, though not all, of their fishing at that time. Returning to the island from a fishing expedition, they proceed at once to feed their young. The parent bird settles down beside the nestling, which without delay begins to pick her beak gently. Presently the parent bird stands up and, lowering its head, opens the beak and disgorges a mass of partially-digested squid and oil; but before it is too late the young bird inserts its bill crosswise into that of its parents, and receives the offering with apparent relish. The young bird is in no way modest in its demands, and continues to beg for more until the supply is entirely exhausted, when the old bird pecks back savagely, or walks off to a safe distance and settles down to rest and sleep.

The black-footed albatross does not visit Laysan in such large numbers as do the foregoing species, and as a consequence they live in more restricted colonies. In their habits they closely resemble their white-breasted cousins.

In the guano beds for which Laysan Island is famous commercially, the workmen often find the eggs of the albatross and the shearwaters bedded in the rock-like guano deposits in a semi-fossil condition.

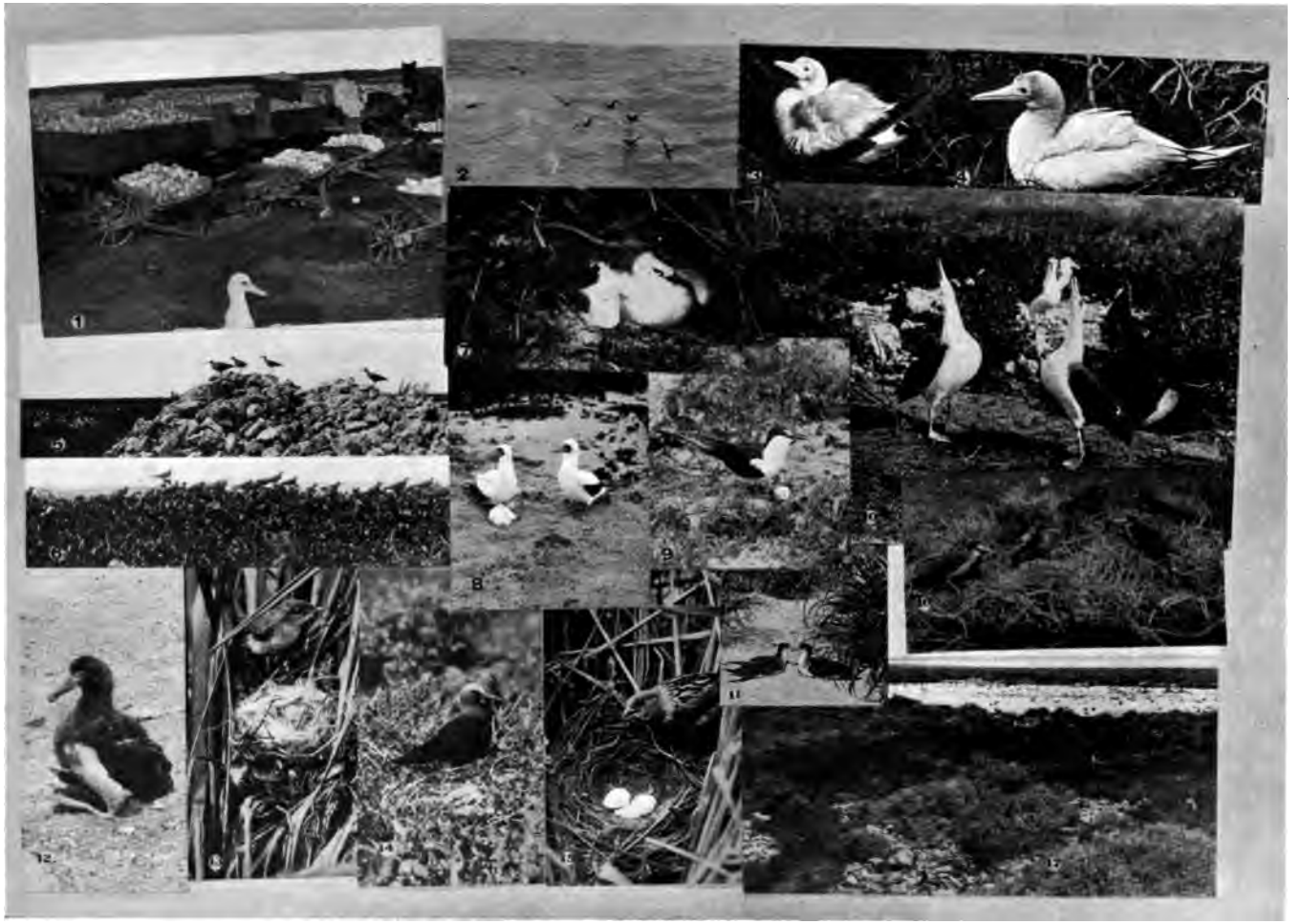

PLATE 79. BIRD LIFE ON LAYSAN.

(For Description of Plate See Opposite Page.)

Nesting Habits of the Man-o'-War Birds.

Of the large sea-birds on Laysan, the nesting habits of the great man-o'-war birds are second in interest only to those of the albatross. Though its habits have gained for it the most undesirable of reputations among its fellows, the species is worthy of more than passing notice. Their nests are rude structures of sticks and vines, in bulk the size of a bushel basket, that are placed on top of the low bushes. On a desert sand island it is not an easy task to secure the necessary material for the hundreds of nests required by the birds in a colony of the size of that on Laysan. As a result the birds have become notorious thieves, stealing from each other without the slightest regard for the ordinary rules governing the possession of house-building materials among birds. When both the owners of a nest chance to leave it at the same time, if only for a few minutes, their neighbors will greedily carry it away, often not leaving a single vestige of the nest to mark the former home of the absent owners.

Both sexes sit on the single large white egg, turn about, seldom leaving it for an instant day or night for fear it will be broken and the nest stolen by their neighbors. They are forced to keep even a closer watch over the naked young than over the egg in the nest, to prevent their defenseless chicks from being carried off and devoured.

In securing their daily rations they have acquired a skill that makes the acts of an ordinary highwayman seem commonplace. Their habit is to establish their colony in the neighborhood of a booby colony. Here they patrol the island up and down, out over the open sea, a few hundred yards from shore, lying in wait for the return of the industrious boobies and tropic birds that have been out sea-fishing. As the birds near the shore heavily laden with fish, the man-o'-war bird gives chase, often a flock of these winged pirates focusing their attack on a single booby. They fly over it, in front of it, and pick it and otherwise buffet and molest it, until, in self-defense, the confused bird lets go its catch of fish one by one. The fish are eagerly caught up in mid-air by the assailants and the attack renewed, until, more times than not, the booby, after a hard day's work securing food for her family, arrives

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Description of Plate.

1. Albatross eggs. The manager of the guano company at one time packed down a few barrels of eggs for use by the laborers, but eggs were never exported from the island. The picture here shown and often published was especially arranged for spectacular photographic effect. 2. Black-footed Albatross in the wake of a steamer. Both the black and the white species follow ships at sea and are called gooneys by the sailors. 3, 4. Two views of an enraged Red-footed Booby. 5. Bristle-thighed Curlews roosting on a pile of guano rock. 6. Colony of Hawaiian Terns—all facing to windward, a habit of sea-birds. 7. Red-tailed Tropic Bird on the nest. 8. Family group of Blue-faced Boobies. 9. Sooty Tern with egg. 10. Laysan Albatross—the end of the dance. 11. Wedge-tailed Shearwaters at home. 12. Young Laysan Albatross; partly fledged. 13. Miller Bird and nest. 14. Hawaiian Tern on a bush of *Chenopodium Sandwicheum*. 15. Laysan canary nest and eggs. 16. Group of Man-o'-war Birds on the nest. 17. General view on Laysan looking to the east across the salt water lagoon.

at her nest in an exhausted condition, without a morsel of food left for the expectant young at home.

During the calm warm days of summer the sea is frequently so smooth that the booby is unable to bring home its usual catch of flying-fish. At such times the man-o'-war birds not only resort to cannibalism, but infanticide as well, in order to satify their demand for food. If by chance the parent bird of a nearby nest should happen to leave its young unguarded, the ever-watchful pirate-bird, with a swoop of wings and a vicious snap of beak, will seize the almost naked, helpless nestling and mount high in the air, dangling the young bird from its beak. When in the bird's judgment the fall will be sufficient to crush the life out of its prey, the man-o'-war bird, with murderous intent, will drop its neighbors' offspring to the ground. The falling nestling is closely followed in its descent by the bird, that it may be first in at its death. If the fall was sufficient to kill the young bird, it is snatched from the ground and gobbled down by the greedy pirate-murderer. If the young bird struggles, it is again carried into the air, this time to a greater height than before, and again allowed to fall to the ground. This performance is often repeated several times before the helpless young bird is pronounced dead, when its body is swallowed by its assassin in a single gulp.

White Terns.

There is not space in one brief chapter to describe the interesting nesting habits of the beautiful white terns or love birds,[22] the colonies of thousands upon thousands of gray-backed,[23] noddy and Hawaiian terns; the shearwaters, petrels and boobies, all of which occur on other islands of the group, but it seems unfair to nature, to Laysan, and to the reader, to fail to mention, even though it must be in the briefest manner, the species that are found nowhere else in the world.

The Laysan Duck.

The sportsman finds it almost impossible to believe that a distinct species of duck, the Laysan teal,[24] could make so small an island its only home, but such is the case. On a recent visit, however, I found this little colony so reduced in numbers that the species could easily be exterminated in a single day with dog and gun. This little teal, a close relative of the Hawaiian duck, is perfectly fearless. On one occasion a pair, out of curiosity, swam up to the bank of the little lagoon where I was partially concealed, and, coming out on the bank, walked up so close to the camera that it was necessary to draw back to bring them into focus on the plate.

The Flightless Rail.

The great natural curiosity of the island is the little flightless rail.[25] The common belief that they are wingless is an error—growing out of the fact that

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[22] *Gygis alba kittlitzi.* [23] *Sterna lunata.* [24] *Anas laysanensis.* [25] *Prozanula palmeri.*

the wings have become so reduced in size as to be almost hidden in the body-feathers, and so weak as to be useless in flight. Almost every square rod of the grassy portion of the island has its pair of rails, and they are, without doubt, the most interesting, industrious and inquisitive creatures in the world. At the slightest alarm they slink into cover under the grass tussocks, only to peer out cautiously in their endeavor to get first-hand knowledge of the cause of their alarm. Of their many interesting habits none is more entertaining than the way in which they secure a portion of their food from the Laysan canary.

Laysan Canary.

The Laysan canary is a sturdy little finch-like bird that nature has endowed with a strong bill. One of its habits is to break open the thin-shelled eggs of the terns and other ground-nesting species during the nesting season. However, the canary is seldom allowed to enjoy the fruits of its labor undisturbed. The little rails are always on the lookout, and at the proper moment will rush out at the canary and, with a great show of fuss and feathers, drive it away from the broken egg. The rail will then calmly spoon up the contents of the egg with its weak, slender bill, leaving the canary to open another egg if it really cares for fresh eggs to eat. As to how this active little rail came to be on the island we can only conjecture. As the species has no near relative that can fly over a wide range, it is probable that the ancestors of the Laysan rail came to the islands very long ago by accident, possibly being lost at sea during the season of migration, or may have been stranded there by the submergence of lands connecting Laysan with other islands of the group. Finding the island small, but well stocked with food and without serious natural enemies, the species doubtless settled down to live the island life. Having but little use for their wings, they gradually lost the power of flight.

The Laysan canary is the best songster on the island, and as a result many of them have been captured by occasional visitors and carried to Honolulu to be kept in cages as pets. On Laysan they are very numerous. Being of good size and absolutely fearless, they are most interesting, often coming into the rough houses built by the guano company, to look for seed or to secure a drink of fresh water. Fresh water is a real luxury to them, though they never care to bathe in it as ordinary canaries do.

The Miller Bird.

The miller bird, as it has been called on account of its unusual fondness for a certain species of miller that is very abundant on Laysan, is a small reed-warbler. This small brown bird is the only representative of this extensive family of insect-eating birds to be found in the native fauna of the group. Ornithologists have been much interested in the discovery of this well-marked species occurring only on this isolated spot of land, since all of its relatives are capable of making extended flights by sea and occur widely distributed in

Australia and China and on various Pacific islands. Like its neighbors, it is quite fearless and is always busy. They often break into a sweet, strong, melodious warble, that seems quite out of place on a low, hot sand island; the song being entirely out of proportion to the size of the bird.

The remaining species peculiar to the island is the Laysan honey-eater. It is an island form of the apapani, a related species that is common in the forests of the higher islands of the group. It is a small bird, red in color, that so clearly resembles its better known relative as not to require description here. While not so abundant as the other species just mentioned, their bright scarlet plumage renders them more conspicuous. Like their cousins, they are especially fond of the nectar of flowers, and their long, slender, curved bills and tube-like tongues make it an easy matter for them to drink the sweet fluid from the blossoms of the Portulaca that grows abundantly about the edge of the lagoon. They are also fond of insects and make many a meal from the large grey millers on the island. They are most regular in their habits, returning hour after hour and day after day to the same bush or flower to search for food.

A number of years ago the Laysan rail was liberated on Midway Island, where it has established itself in a thriving colony. The Laysan canary has also been introduced on Midway and has found conditions there entirely suitable to its habits. In 1909 Mr. D. Morrison purchased a pair of the common yellow canaries [26] in Honolulu and soon after liberated their young on Midway. They have increased in numbers until it was estimated that there were more than a thousand birds on the island by the end of the nesting season of 1914. They are sweet songsters, and although not quite so friendly as the Laysan finch, they will feed with a person standing within a yard of them. The future of this colony will be followed with much interest by those who are interested in the introduction and naturalization of song and game birds, since it furnishes an excellent example of a species returning to its natural wild habits after centuries of confinement and artificial breeding and feeding.

CHAPTER XXIV.

BIRDS OF THE MARSH, STREAM AND SHORE.

More than half of the complete list of birds recorded as occurring in the Hawaiian group are shore and water birds. This part of the fauna includes resident species, regular winter migrants, and a considerable list of occasional or accidental visitors. As those species that are met with in Hawaii only at irregular intervals are seldom seen and cannot be expected to contribute much to the numerical strength of the meager bird population, the present chapter deals only with the more common forms.

We have observed in an earlier chapter that the city as well as the

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[26] *Frangilla canaria.*

farming lands on the lower levels about all the islands are without native birds of any kind. Fortunately, this is not true of the ponds, marshes, streams and the sea-shore, as the waters of Hawaii are still inhabited by several characteristic forms. Unfortunately, some of the species of the region are now very rare, while others that are more common are of more than usual interest, since they are not met with elsewhere in the world. The majority of the birds belonging to this low-land section, however, are representatives of wide-ranging species that visit Hawaii as a winter resort to escape the rigors of the climate in the far north where most of the shore and water birds repair every summer to nest and rear their young.

The Golden Plover.

Conspicuous among the migrants visiting Hawaii each year are the golden plover, the wandering tattler, the turnstone and the sanderling. A stroll along the sea-shore, especially in the country districts during the winter season, will be rewarded by a sight of one or more flocks of at least some of these species as they follow up the receding waves in search of the dainties that are left strewn on the sand by the sea. Often the plover[1] will be seen in large numbers, feeding on the upland, where, in the freshly-plowed fields or in the newly-planted cane or on the open grass lands, they find an abundant supply of worms and insects. They doubtless render a great service to the planter and farmer during this season, and are entitled to all the protection they receive in return.

When the plover arrive at the islands in the autumn, from the summer spent in the far north, they are usually in poor flesh. But when we think of the long journey they must make over the three thousand miles of ocean without a rest, the wonder is that they do not perish on the way. Just why the plover and all the other migratory birds undertake these wearisome flights across the wild open ocean, it seems must ever remain a mystery. Without doubt, when storms are encountered many must lose their way and go down to watery graves or, thrown from their course, must fly for days over the great dull expanse in search of land. Perhaps it was in some such accidental way that the first plover happened to visit Hawaii in the long ago. Since it doubtless found the islands a pleasant land, it seems almost incredible that a helpless wanderer should ever put to sea again in search of the distant land from whence it came. But the instinct to migrate to the far-away north and rear a brood and return again to these little islands over the sea must have been very strong—strong enough to carry it and its descendants back and forth year after year. Doubtless such is the story of the beginning of the colonies of most, if not all, of the different species of migratory shore and water birds that visit Hawaii each year.

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[1] *Charadrius dominicus fulvus.*

Old 'Stump Leg.'

It is interesting to know that once the journey is successfully made, barring accident the voyager is able ever afterwards to make the passage with unerring accuracy. An interesting case in point is the record I secured from Mr. Max Schlemmer, who for several years was the manager of the colony of laborers formerly stationed on the little sand island of Laysan. This island is but a mile and a half across by two miles in length. Nevertheless, plover occur there in large flocks each winter season.

On one occasion a fine male bird that was in the habit of roosting every night on a little mound of sand a few rods from the door of the manager's house, attracted his attention as it fluttered about on the sand apparently unable to fly. Picking it up it was found that a bunch of hair and refuse was wound about the bird's foot and leg, and that this had been added to with dirt and sand until a bunch large enough to weight the bird down had formed. In its efforts to fly it had broken its leg and was in a pitiable condition. The manager amputated the leg at the fracture and set the bird at liberty. To the surprise of all, it healed perfectly. The stump-leg furnished a mark for identification that served to distinguish the bird from its fellows, and it naturally became an object of interest in the colony. It remained about the island all winter, returning each night to its favorite roosting-place on the sand mound. It became unusually tame and fearless. When spring came, however, it responded to the most powerful call that stirs the avian brain, the homing instinct, and with its fellows left the wave-washed shores of Laysan to make the long flight back from whence they came, seemingly for no more intelligible reason than that they had made the journey before.

Naturally, the manager bade good-bye forever, as he thought, to his bird neighbor the first night it failed to return to its roost. But being a seafaring man, and accustomed to the excellent discipline of keeping a ship's log-book, whether on land or sea, he accordingly made a note of the fact with day and date and dismissed the incident from his mind. The summer passed, and one early autumn day the whole colony was thrown into a state of excitement by the announcement that the stump-leg plover had returned the night before and had been found that morning occupying his sand-pile roost. The bird was apparently as much at home as though a summer cruise to some distant land was a regular occurrence and a matter of little consequence. Naturally, so important an event as the return of the stump-leg plover to its winter home was made a matter of record in the log for the day. The bird more than ever became the object of interest and concern on the part of all hands, for had he not accomplished a feat entitling him to the highest respect among seafaring

(Description of Plate Continued from Opposite Page.)

Petrel [Oeoe] (*Oceanodroma cryptoleucura*). 5. Hawaiian Tern [Noio] (*Micranous hawaiiensis*). 6. Bonin Petrel (*Æstrelata hypoleuca*). 7. Hawaiian Coot [Alae keokeo] (*Fulica alai*). 8. Hawaiian Hawk [Io] (*Buteo solitarius*); light plumage. 9. Hawaiian Gallinule [Alae] (*Gallinula sandvicensis*).

PLATE 80. HAWAIIAN BIRDS OF VARIOUS ORDERS.
[From plates in Aves Hawaiiensis.]

1. Wandering Tattler [Ulili] (*Heteractitis incanus*). 2. Hawaiian Duck [Koloa maoli] (*Anas wyvilliana*). 3. Hawaiian Goose [Nene] (*Nesochen sandvicensis*). 4. Hawaiian Stormy

(Description of Plate Continued on the Opposite Page.)

men? Had not this bird, without a chart or compass, started from a given point in the very middle of the Pacific Ocean, and made a cruise extending over several months, and at least 6000 miles of trackless water, returned again, arriving by night at the very point of starting? Certainly old "Stump-leg" was an able seaman and a master navigator.

But this remarkable record does not stop with the report of the single trip. The log-book records that, for five years, each fall this bird returned to Laysan, arriving each year at almost the same date and departing in the spring with equal punctuality for parts unknown. But, at last, "Stump-leg" failed to return. Whether he was killed by hunters in Alaska or gave out on the weary and dangerous journey, or lost his bearing and went down struggling against fate, or died a natural death, will never be known; but certain it is that his voyage to and from Laysan Island and the records made of them constitute a most interesting and valuable incident, throwing much light on the unerring accuracy of the mysterious instinct which, doubtless through hundreds and perhaps thousands of generations has served to guide our feathered friends in their migrations to and from Hawaii.

It requires but a few weeks in the islands before the plover are all in good condition, and long before they leave for the north the following spring they are plump and heavy with fat. When in that condition everyone knows that the plover is a toothsome morsel. In the old days it was much prized as food by the natives of Hawaii, who exhibited great skill in the capture of the wild birds. So skillful were they in imitating the plover's peculiar whistle that they were often able to lure the birds close enough to the hunter to enable him to pelt them with stones. Another less sportsmanlike method was to bait a fish line with a tempting worm. The bait was placed along the beach at a promising spot and the birds called to partake of it.

It was customary to cook the kolea (plover) and, indeed, any of the game birds, by filling the body cavity with a smooth hot stone, that was especially suited to the purpose. The bird, stone and all, was then wrapped up in a neat package of ti leaves and sufficient time allowed for the heat from the stone to accomplish the desired result.

The Turnstone, Sanderling, Tattler and Curlew.

Like the foregoing species, the turnstone,[2] the sanderling[3] and the tattler[4] arrive in Hawaii late in August or September and leave the following April by thousands. However, there are usually a few individuals of each species that fail to leave for the north. An examination of the summer birds proves them to be birds that are young and barren or too weak to undertake the long flight.

Of the remainder of Hawaii's migratory wading birds it is only necessary here to mention the bristle-thighed curlew,[5] as such other species as occasionally occur are rarely if ever seen by the ordinary observer.

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[2] *Arenaria interpres.* [3] *Calidris arenaria.* [4] *Heteractitis incanus.* [5] *Numenius tahitiensis.*

The curlew is by no means abundant on the large islands, but on the low-lying islands to the northwest they are fairly common. The curlew are much larger birds than the plover, and are such conspicuous objects when they do visit the inhabited islands that the securing of a specimen is always a real event. This fine game bird is easily recognized, as it is the only shore bird that has a bill about three inches in length that is slightly curved downward. It derives its common name from the peculiar feathers of the thighs, which terminate in long bristle-like points. It is of interest to know that this species visits the sea-coast of almost all of the hundreds of islands in the Pacific ocean at all seasons, but curiously enough no one has ever found its nest and eggs on any of them.

The Hawaiian Stilt.

A bird that is occasionally seen along the sea-coast or about the salt-water marshes is the peculiar Hawaiian stilt.[6] Its long neck, black back, white breast and unusualy long pink legs make it a conspicuous and interesting object. Unlike any of the foregoing, it is a resident of the islands throughout the year. Its ancestors, doubtless, long ago gave up the habit of making the useless journey away over the ocean every summer to rear their young. The Hawaiian stilt, therefore, is found nowhere else in the world. As it is rare even in Hawaii it is an interesting bird, since it has doubtless come to differ from its near relatives by reason of the fact that it has long been isolated from others of its kind.

Black-Crowned Night Heron.

No one who visits the sea-shore at sundown or is abroad at sunrise will fail to see the long-legged, black-crowned night heron,[7] as it flies from its home in the valleys to its fishing grounds on the tide-flats or along the mullet-pond walls. While this heron lives throughout the year in the islands, it has not been long enough cut off from the rest of its relatives to become a distinct species, as it is still impossible to distinguish it from specimens of the same heron collected in America.

They feed almost entirely on fish, the mullet being a favorite with them. In certain localities they levy a considerable toll on the mullet ponds in the vicinity of their rookeries. They secure their food along the sea-shore, mostly at night, and retire during the daytime to the thick woods in the mountain valleys, where they nest in colonies. Their nests are bulky affairs made of sticks, and often are two feet in diameter. Sometimes a dozen nests will be found in a single tree. The eggs, which are pale blue in color, are as large as small hen eggs.

The old birds, with their long necks and legs, are very picturesque as they crouch in the treetops or wing their heavy flight about the valleys. The black back and black crown are in contrast with the fine bluish-gray color of the body

[6] *Himantopus knudseni.* [7] *Nycticorax nycticorax nævius.*

and wings, all of which are marks of maturity. The male during the mating season is designated from the female by a pair of long white streamers that curve gracefully down from the back of the head. The young birds are always spotted and mottled in various shades of brown, buff and white, and are so different in appearance in this immature plumage that the Hawaiians, even though they were very close observers, gave to the old and young aukuu different names.

The Coot and Gallinule.

The Hawaiian coot [8] is almost as large as a small fowl. It is seldom seen except in the fresh-water ponds, and brackish and fresh-water marshes. This curious bird and its cousin the Hawaiian gallinule,[9] a bird that in size and general habits it resembles very much, are Hawaiian species that have near relatives on the mainland from which they differ but slightly. The coot is a dark slaty-gray color, and is peculiar in that its toes, instead of being webbed as they are on a duck's foot, are provided with conspicuous lateral lobes or flaps which enable it to swim with great speed and to dive almost at the flash of a gun. The upper bill has a curious large white shield over its base. This white shield and the lobed feet help the beginner to identify the bird and prevent it being mistaken for the gallinule. The latter has the frontal shield, a vermillion red, and the toes are without the curious lobes. Both species build their nest of dead rushes and grasses, placing them in the swamp near their favorite haunts.

The Legend of Maui and the Alae.

The Hawaiians have a very interesting story that seeks to explain how the alae or gallinule acquired the red spot on its forehead. According to the legend, the great Maui, who dwelt in the islands before the process of making fire was invented, had four sons, who were fishermen. Each morning at sunrise they would take their canoes and go offshore to a favorite fishing ground. One morning they espied a fire on shore and, being desirous of having their food cooked, rowed to the spot where the fire had been seen, but lo! no fire could they find. The next day they repeated the experience and were again disappointed. After repeated failures they resorted to strategy. Dressing up a huge gourd to resemble a man, they placed the dummy in the boat as a substitute for one of the four fishermen, and sent the canoe out to fish as usual.

The man on shore crept close to where the fire had been located and waited patiently. To his surprise he found it was the alae that had guarded the secret of the fire so well.

Knowing Maui had but four sons, this cautious bird had waited each time until they were all away fishing before it dared to light the fire, and keeping a sharp watch it scratched it out again when they started home with their boat. This time the dummy in the boat had fooled the bird. At the proper moment

[8] *Fulica alai.* [9] *Gallinula sandvicensis.*

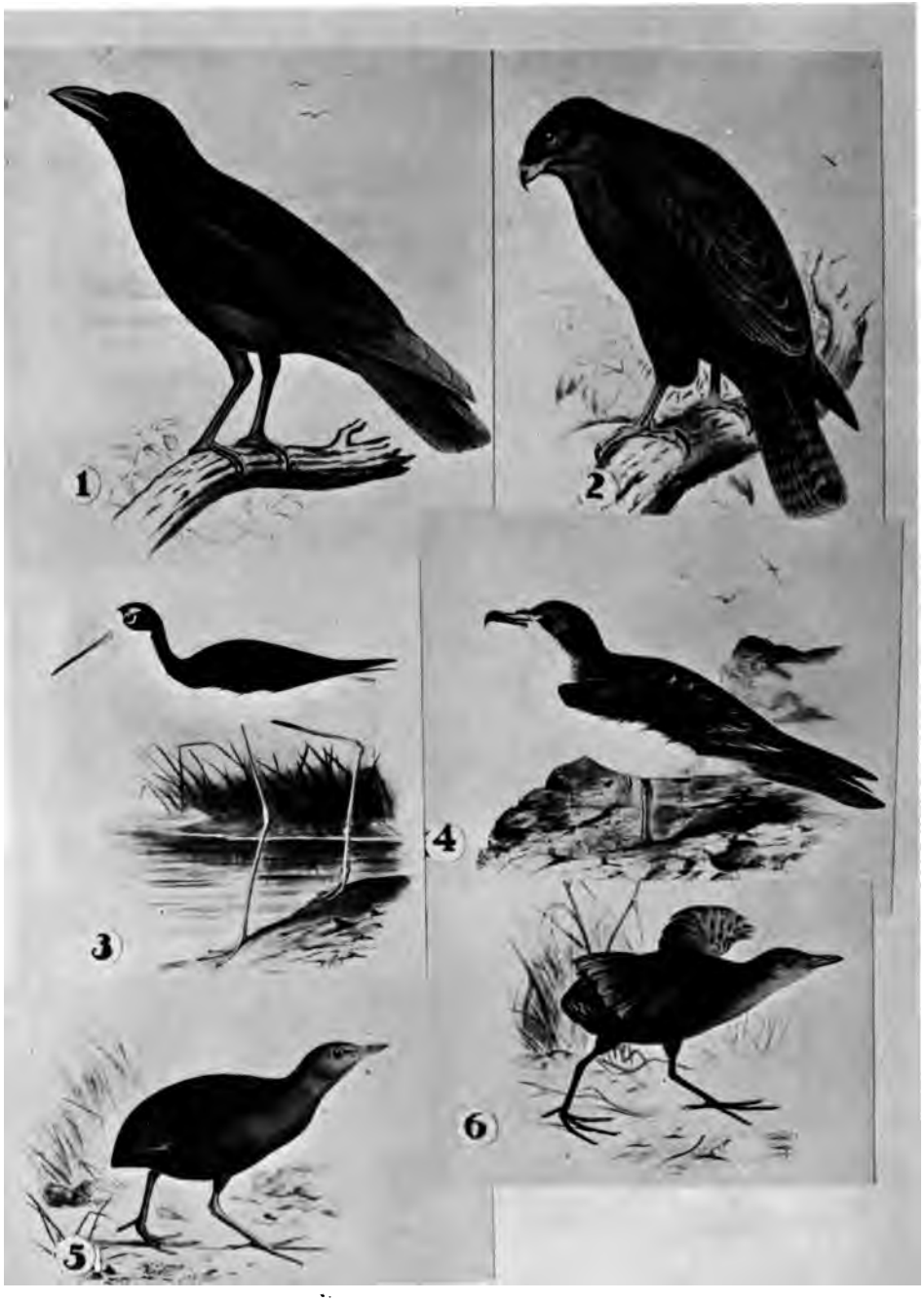

PLATE 81. SIX INTERESTING HAWAIIAN BIRDS.

[From plates in Aves Hawaiiensis.]

1. Hawaiian Crow [Alala] (*Corvus hawaiiensis*). 2. Hawaiian Hawk [Io] (*Buteo solitarius*) dark plumage. 3. Hawaiian Stilt [Kukuluaeo] (*Himantopus knudseni*). 4. Wedge-tailed Shearwater [Unukane] (*Priofinus cuneatus*). 5. Hawaiian Rail [Moho] (*Pennula ccaudata*. 6. The same showing the expanded wings.

the oft-defeated fisherman leaped from his hiding place and, seizing one of the birds, threatened to kill it for hiding the secret of the fire from them. The bird very ably argued that if it should be killed the secret of the art of making fire would die with it. At last, just in time to save his neck and after considerable parley and repeated attempts at evasion, the bird finally divulged the ancient art of making fire by rubbing one dry stick on another. So exasperated had the son of Maui become before he succeeded in producing fire, for he was told to rub together first one thing and then another, that at last he rubbed the top of the bird's head until it was red with blood, and the red spot has remained thereon to this day.

The Hawaiian Duck.

Although both the gallinule and the coot were eaten by the Hawaiians, they were not so highly esteemed as was the Hawaiian duck,[10] a small species that formerly was plentiful in the streams and marshes on all the large islands. Of recent years they have become very rare except on the Island of Kauai. It is thought that the mongoose, together with the sportsman, have brought about this unfortunate state of affairs, since this species is peculiar to these islands. As a matter of fact, such foreign ducks as the shoveler,[11] with its spade-like bill, and the pintail,[12] with its sharp-pointed tail, and other less common species that visit the islands each winter, coming down from the northwest coast, are now much more liable to be shot in the group, during the open season, than is the native Hawaiian species. As with the shore birds, there are other species of ducks, and occasionally even geese, that from time to time wander from Alaska on their migrations; but their occurrence is scarcely ever observed by other than the professional sportsman.

CHAPTER XXV.

BIRDS OF THE MOUNTAIN FORESTS.

With the shore, the marsh and the ocean birds considered in other chapters, we come now to the peculiar and therefore more interesting part of the Hawaiian bird fauna, namely, that which is at home in the mountain forests. The exploration of these almost impenetrable, dense, moist, often cloud-swept jungle-like forests is by no means an easy task; but in order to see the Hawaiian birds outside of a museum collection, it is necessary to explore them, since it is there alone that the curious forms of bird life for which Hawaii is noted are found.

Unfortunately, many of the more interesting forms are either extinct or so rare that they are no longer to be seen alive. Of the forms that still exist, a few species are sufficiently abundant and conspicuous in song and color to give an interesting touch of life to the forest that adds not a little to the pleasure of a holiday spent in the mountains.

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[10] *Anas wyvilliana.* [11] *Spatula clypeata.* [12] *Dafila acuta.*

The Elepaio.

A list of fifty-six species of living and extinct passerine birds are all that has been known to exist in the forests of the inhabited islands of the group. This small list must be further reduced by sixteen species which are now regarded by ornithologist as extinct. Of the remaining forty species, which are about equally distributed among the six islands, there are none better known or more commonly met with than the Hawaiian flycatcher, or elepaio of the natives.

Kauai, Oahu and Hawaii still have living species of this fearless little brown bird that on each island can be recognized at once by its pert air and the saucy cock of its fan-shaped tail. They are common on the mountainside all the way from the sea to well up into the higher levels. When hidden in the forests they are easily identified by their curious, loud, clear, insistant call—"elepaio," which is varied by a kissing noise as well as by a number of other whistled notes and calls.

The elepaio [1] is one of the best known of any of the Hawaiian birds. Its nest is a beautiful little structure about two and a half inches in diameter, that in appearance is not unlike that of the humming-bird. It is composed of very fine grass, mosses and lichens, and is placed in the fork of a tree, usually but a few feet from the ground. While the elepaio is a bird famous in song and story on all of the islands, and according to David Malo was formerly used for food, it seems not to have been seriously reduced in numbers and still remains the most abundant Hawaiian species.

The Apapane and Iiwi.

The species most commonly noted by strangers, however, is the beautiful dark blood-red bird, the apapane [2] of the natives. It is about five and a quarter inches in length and can readily be distinguished from the beautiful scarlet iiwi,[3] which is a slightly larger and more brilliant bird, with the bill and feet vermilion or at least not black, as is the case with the apapane.

Both these species of red birds occur in the forest on all the larger inhabited islands in favorable localities from near the sea-shore to the upper limit of the large forest trees, but they are most abundant at from two to four thousand feet elevation. Both are equally fond of nectar, and both frequent the flowering ohia trees. The two species are perhaps the most easily observed by visitors in the vicinity of the Volcano House on Hawaii, where the pleasant though somewhat monotonous song of the apapane can be heard from early until late.

Amakihi

All the larger islands are inhabited by a small green-and-yellow or olive-green bird [4] with a curved beak, known as the amakihi. While they differ

[1] *Chasiempis gayi* = Oahu, *C. sclateri* = Kauai, *C. sandvicensis* = Hawaii.
[2] *Himatione sanguinea.* [3] *Vestiaria coccinea.* [4] *Chlorodrepanis* spp.

PLATE 82. SOME SONG BIRDS OF THE HAWAIIAN ISLANDS.

[From plates in Aves Hawaiiensis.]

1. Yellow-tufted Honey-eater (*Moho apicalis*): Oahu—extinct. 2. Kauai Akialoa (*Hemignathus procerus*): Kauai. 3. Puaiohi (*Phaeornis palmeri*): Kauai. 4. Ulaaihawane

(*Description of Plate Continued on the Opposite Page.*)

slightly in size and color from island to island, they all belong to one genus and are easily recognized as one of the most common and widely distributed species. They are nectar-feeding species and are frequently seen in company with the red species just mentioned. They are also fond of insects and spend much of their time searching through the foliage. The call note of the amakihi is a sweetly-whistled "tsweet," which is easily imitated. Their song is a short trill, and when it is at its fullest is loud and penetrating but not very musical.

All of these birds (as, indeed, are all of the birds belonging to the family *Drepanididæ*) are characterized by a very strongly-marked and peculiar odor. This goat-like scent is so peculiar and persistent in this family of birds that often after they have left the spot the air retains a musk-like smell. The nest of the amakihi is a simple structure of twigs, leaves and roots and is usually, though not always, near the ground.

The Genus Oreomystis.

There is a small olive-green bird occurring on Hawaii, belonging to an entirely different genus[5] that is so similar in appearance to the species of amakihi found in the group that the Hawaiians themselves did not give it a separate name. Several species on the other islands, however, are easily recognized, the adult males especially differing greatly in color, voice, habits and general appearance from the species of amakihi to be found on the respective islands.

The difference between the two genera which would serve to most readily distinguish them in the field, is that instead of feeding almost entirely on insects and nectar from the flowers and leaves, as is the habit of the amakihi, all of the species of *Oreomystis* feed in a large part on insects secured from the trunks and limbs of the forest trees and bushes. They are all expert climbers, working either upward or downward and along the upper and under side of the horizontal branches. The difference in color of the species on the different islands is a most remarkable feature, since gray-green, olive-green, yellow-olive, yellow and bright red species occur.

Thrush and Finch-like Birds.

The five genera mentioned above are represented on all of the large islands by one species or another. A large brown thrush-like bird[6] that is a remarkable songster, and the stocky, olive-green yellow-headed ou[7] are the two species that are next in abundance. Their representatives on Oahu have been extinct for many years, but on one or the other of the islands one or both are occasionally seen by the casual observer about camps and mountain houses.

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[5] *Oreomystis.* [6] *Phæornis* spp. [7] *Psittacirostra psittacea.*

(Description of Plate Continued from Opposite Page.)

(*Ciridops anna*): Hawaii. 5. Kona Thick-bill (*Chloridops kona*): Hawaii. 6. Nukupuu (*Heterorhynchus hanapepe*): Kauai. 7. O-o (*Moho nobilis*): Hawaii. 8. Maui Parrot-bill (*Pseudonestor xanthophrys*): Maui. 9. *Heterorhynchus lucidus*: Oahu—extinct. 10. Akialoa (*Hemignathus obscurus*): Hawaii. 11. *Palmeria dolei*: Maui, Molokai, a very rare species. 12. Molokai o-o (*Moho bishopi*): Molokai, very rare.

PLATE 83. SOME RARE AND EXTINCT BIRDS OF THE MOUNTAIN FORESTS.
[From plates in Aves Hawaiiensis.]

1. Viridonia (*Viridonia sagittirostris*): Hawaii. 2. Black Mamo [Hoi] (*Drepanorhamphus funereus*): Molokai, very rare. 3. Kipi (*Hemignathus lichtensteini*): Oahu, extinct.

(Description of Plate Continued on the Opposite Page.)

Still rarer are the various species of the genus *Loxops* or the akepa, which are foxy-red or orange color, according to the age and the species of the bird. As they feed chiefly upon the insects secured from the foliage of the trees, they are very active little creatures; they resemble the olive-green amakihi in habits, and although possessed of a short finch-like bill, they may readily be mistaken in the treetops for their cousins with the slender curved beaks. The striking peculiarity of all the species, however, is that the beak is not symmetrical. The tips of the mandibles cross each other in much the same fashion as that of the common "crossbill" finches elsewhere.

The remaining species are too rare to be met with, except by the merest chance, by any one save a professional ornithologist, and even then the enthusiast is often forced to remain for weeks in the wildest mountain forests before even hearing the voice of the species sought, and more times than not the whole effort to see or secure a specimen results in the most depressing disappointment.

Rare and Extinct Birds.

Of the species that have been known to inhabit the islands in times past, no fewer than twenty are now so rare in collections, and for years have been so scarce in the mountains, as to entitle them to have their names entered on the list of species no longer in existence, or at least bordering on extinction. The Island of Oahu can make the melancholy boast that it has a greater list of extinct birds, in proportion to the total number of species known from the island, than any other like area in the world. On Hawaii the moho [8] has been extinct for years, having been exterminated, it is thought, by the domestic cats that long ago ran wild. As it was a small flightless rail resembling its cousin on Laysan, it is doubtful if it would have been able to survive the inroad of the more recently introduced mongoose, which has been everywhere merciless in its attack on ground-nesting birds.

The fine black mamo [9] was brought to the verge of extinction by the Hawaiians years ago. From its rump the natives secured the rich golden-yellow feathers used in the making of their feather cloaks, helmets and leis.

The o-o [10] likewise was driven to the verge of extinction for similar reasons. When the mamo became rare the natives began to substitute the yellow feathers growing under the wings of the o-o for the rump feathers of the former. Though they were not so rich in color, they made acceptable substitutes, and as a result these beautiful birds are now practically all gone on Hawaii, while on Molokai and Kauai the two species belonging to the same

[8] *Pennula ecaudata.* [9] *Drepanis pacifica.* [10] *Moho nobilis.*

(Description of Plate Continued from Opposite Page.)

4. Maui Amakihi (*Chlorodrepanis wilsoni*): Maui. 5. Hawaii Half-bill (*Heterorhynchus wilsoni*): Hawaii. 6. Mamo (*Drepanis pacifica*): Hawaii, extinct. 7. Alauhiio (*Oreomystis montana*): Lanai. 8. *Chætoptila angustipluma*: Hawaii, extinct. 9. *Loxops rufa*: Oahu, extinct. 10. *Loxops ochracea*: Maui, becoming quite rare. 11. *Oreomystis maculata*: Oahu. 12. *Rhodacanthis palmeri*: Hawaii, very rare.

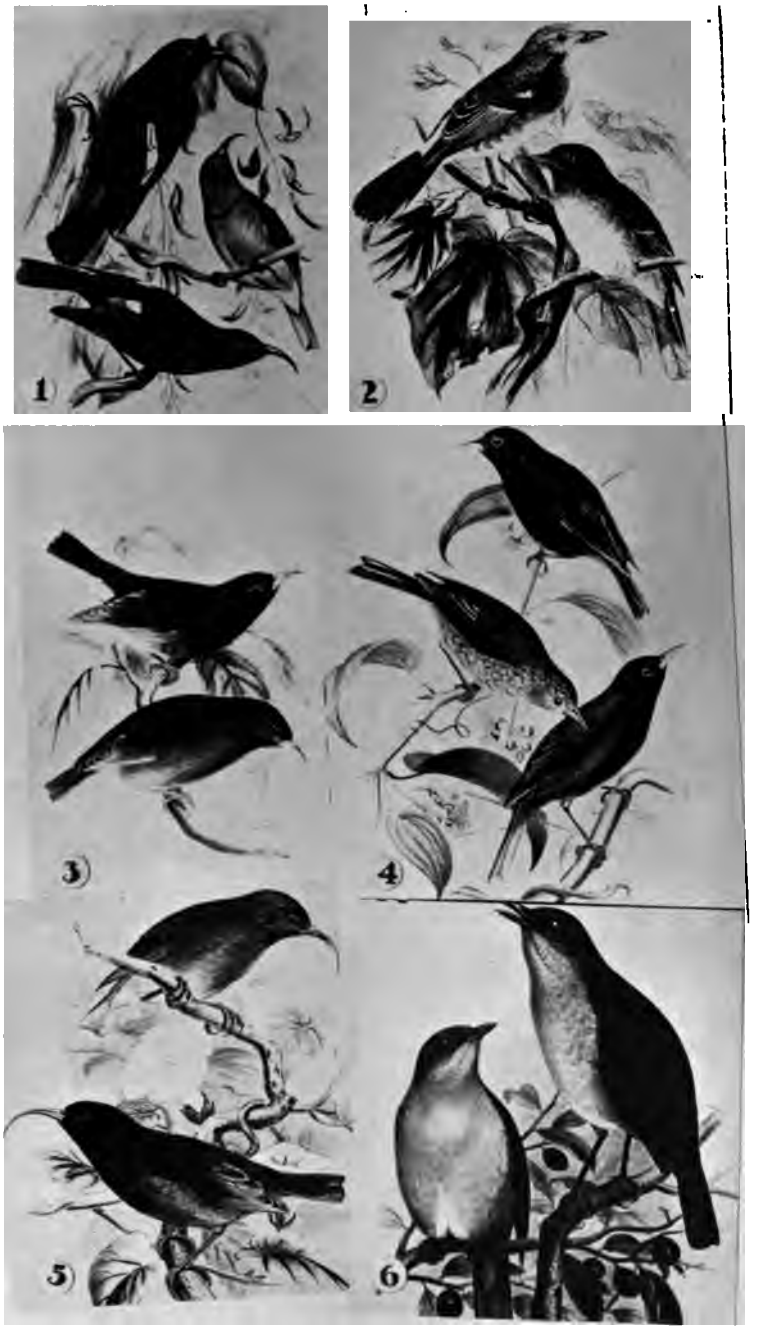

PLATE 84. SIX FAMILIAR MOUNTAIN BIRDS.

[From plates in Aves Hawaiiensis.]

1. Iiwi (*Vestiaria coccinea*): found on all the islands. 2. Kauai Elepaio [Apekepeke] (*Chasmeipis sclateri*): Kauai. 3. Kauai Amakihi (*Chlorodrepanis stejnegeri*): Kauai. 4. Apapane (*Himatione sanguinea*): all islands. 5. Maui Half-bill (*Heterorhynchus affinis*): Maui. 6. Hawaiian Thrush [Oma'u] (*Phaeornis obscura*): Hawaii.

genus are rapidly dying out, apparently of their own accord, or at least from other unassignable causes. The Oahu species[11] has long been extinct.

Hawaiian Duck and Goose.

The Hawaiian duck,[12] the gallenule and the coot are diminishing in numbers on all the islands where the mongoose is found; while the puffin, the petrel and the native goose[13] are all subject to its toll.

All of these birds are becoming extinct from known causes, but there are species which have died out for no assignable reason. The splendid *Chætoptila angustipluma* of Hawaii is a case in point. Though it was rare when first discovered by naturalists, it has not been seen in the forests from that day to the present.

Likewise, there seems to be no adequate explanation for the extinction of at least five of the six species that are now known from only a few museum specimens collected by early naturalists, as only one of the extinct species, namely, the Oahu mamo, was ever killed by the natives for their feathers. Although numerous theories have been advanced, the cause of their extermination will doubtless ever remain one of nature's own secrets.

In considering the future of the Hawaiian birds, especially those that have been rare or very limited in their distribution, we must remember that the forest areas are diminishing owing to the devastation of animals, the ax and the settler, and that in consequence the birds are constantly being brought into sharper competition among themselves and into a struggle with a different if not a new environment.

Already several species that a decade ago were regarded as fairly common in certain localites have disappeared from them entirely, while others are only found after long and diligent search.

Hawaiian Crow.

An interesting phase of Hawaiian bird life is shown by the native Hawaiian crow.[14] It occurs on a certain portion of one island only, and there over an area from which it never seems to attempt to pass. Having originally gained a foothold in the Kona and Kau districts of Hawaii, the bird seems to be unwilling to extend its range to the windward forests that adjoin is habitat, even though they are known to abound in suitable food.

The *Viridonia*[15] is a handsome olive-green bird which furnishes a still more remarkable instance of a restricted habitat. This, one of the rarest of Hawaiian birds, is only found on Hawaii, and there it is confined to an area of a few square miles and is absolutely unknown outside this little valley region, where it was so rare as to be unknown to the native inhabitants.

The Black Mamo.

The hoi or black mamo[16] is confined to the Island of Molokai. There it

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[11] *Moho apicalis.* [12] *Anas wyvilliana.* [13] *Nesochen sandvicensis.* [14] *Corvus hawaiiensis.*
[15] *V. sagittirostris.* [16] *Drepanorhampus funerea.*

finds forest conditions that are suitable to its habits over only a very limited portion of the mountain area of the island. While it is an active, energetic bird, it has apparently never attempted to cross the channels to the nearby island of Maui. For a hundred years at least it has been a rare bird on Molokai, so rare, indeed, that in 1907 the writer secured but three specimens as a reward for seven weeks spent in the mountains in a search devoted to locating this interesting and curious species.

Still another interesing example of limited distribution among Hawaiian birds is that of the nene or Hawaiian goose, which is confined to the Island of Hawaii, where it leads a life of seclusion, high up on the mountainside, seldom if ever descending to the sea level. The Hawaiian duck is more widely distributed, having occurred in considerable numbers on all islands of the group. Unfortunately, since the introduction of the mongoose it has been quite rare except on Kauai, where the mongoose has never been liberated.

A Native Hawk and Owl.

The Hawaiian hawk or io[17] occurs only on Hawaii, where it is still fairly common. The Hawaiian owl[18] occurs on all the large islands. It is quite closely related to the short-eared owl, common on the American continent. Since it differs from the American species only in minor details, it is regarded as an island form of that species which has been reduced in size through isolation. Like the coot and mud-hen, it is one of the more recent arrivals that have made the islands their home long enough to allow the principles of evolution, especially those involved in isolation, to produce slight, though easily recognizable, changes in the appearance of the species. Though the natural history of the Hawaiian birds is of much general interest, it will be seen that the subject of the evolution of the various species presents material for consideration that is of deep and absorbing interest to all.

The Family Drepanididæ.

The family *Drepanididæ*, which includes the majority of the song birds of Hawaii, is perhaps the most remarkable example of the evolution of a group of birds to be found anywhere. The family which is peculiar to the islands, includes about forty species that are found nowhere else in the world. While they are all much alike in their general structure, they differ amazingly in the form of bill and also exhibit striking differences in the color of the plumage. In almost all other families the form of the bill is quite uniform among the species that belong to it. That organ usually bears a close connection with the feeding habits of the group, and these are usually very nearly the same for all the species in the family. But among the *Drepanididæ* of Hawaii we find them fitted by their structure to almost every kind of life for which a song bird in the tropics can become adapted. This adaptation of the bill has

[illegible]

PLATE 85. COMMON HAWAIIAN BIRDS.

[From plates in Aves Hawaiiensis.]

1. Hawaii Elepaio (*Chasiempis sandvicensis*): Hawaii. 2. Kamau (*Phœornis myadestina*): Kauai. 3. Ou holowai (*Loxops cæruleirostris*): Kauai. 4. Akikihi (*Oreomystis bairdi*): Kauai. 5. Oahu Elepaio (*Chasiempis gayi*): Oahu. 6. Apapane (*Himatione sanguinea*): all islands. 7. O-u (*Psittacirostra psittacea*); formerly on all islands. 8. O-o a-a (*Moho braccatus*): Kauai. 9. *Loxops ochracea*: Maui.

led to some most remarkable changes. From the firm, straight bill of the genus *Oreomystis*—the genus supposed to most closely conform with the ancestral form which may have come from America in very remote time, and the form from which all other genera of the family are supposed to have evolved—we have widely different types of bills developed.

In one branch of the family the bill passes through several genera, each slightly modified, until the normal straight bill becomes an unusual one, very long and slender and singularly curved, with a tubular tongue, especially adapted to securing the nectar from long tubular flowers. The opposite branch leads off by gradual degrees to where a short thick bill of astonishing strength terminates the line of evolution in *Chloridops kona*—a grossbeak-like bird that confines its food habits to cracking the flint-like seeds of the bastard sandalwood. Between the long, slender, curved honey-eater beak and the heavy finch-like beak are all manner of special forms. In one the bill is parrot-like; in another it is suited to a fruit diet, so that many forms of bill occur.

Hawaiian Birds Becoming Extinct.

With the high specialization of the bill these birds have lost their power of adaptation. As most species are confined to but a single island, and in some cases to a single district, and there to a single species of tree, we can see how difficult it would be for them to adjust themselves to any sudden change in their environment after they had gradually become fitted through countless centuries for the conditions that existed in any particular locality. Developed under conditions most unusual and peculiar—each within its own chosen and restricted sphere—change of any sort, and competition however slight, is likely to find them unprepared to compete, though some species are better endowed to take part in the struggle than are the majority. In the light of their own past history, they seem strangely susceptible to any change that may occur. When the few remaining species are gone there will be left behind them, as tokens of their existence, only a few dried skins in the museums of the world and a few meager pages in such books as this, telling too little of their life history and habits.

CHAPTER XXVI.

HAWAIIAN FISHES: PART ONE.

The waters of Hawaii have long been celebrated for their fishes of many peculiar habits and characteristics, odd shapes, and remarkable size and color. As a result, so much has been written in a popular and scientific way concerning them that they are perhaps better known than any other form of life about the islands.

Fishing in Former Times.

Doubtless fish have always been one of the chief articles of animal food for the natives, and a visit to the busy markets will not only repay one for the trouble, but convince him that the business of fishing still constitutes one of Hawaii's important industries. The name i'a was given by the Hawaiians to all food products secured from the sea, "whether they moved or not." But for our purpose we will speak only of the fishes, reserving the many other interesting forms for discussion in other chapters.

As has been said in the account of the people, fishing in former times was associated with much religious ceremony and idol worship. Altars and heiaus, especially devoted to the needs of the fishing class, were very common. The fish gods, more numerous than the heiaus, were faithfully worshipped by the fishing class and their every tabu and requirement most studiously observed. Before the fishermen would go out on their expeditions, everything that could be done to placate the gods would be carried out by the devout.

However, we are told that in those days, as in these, there was a certain class, more skeptical than the rest, who went fishing whenever they chose to do so, without observing any religious ceremonies whatever.

Fishing Equipment of the Ancient Hawaiians.

There was a great variety of implements and apparatus employed by the fishermen, and their description and enumeration seems hardly necessary here; but it is of interest to know that they had devices for capturing every kind of creature inhabiting the waters about the islands, with the single exception of the whale.

The canoe was, of course, the most important part of the equipment of a fisherman. These were almost invariably made of koa. Many of the older ones were fashioned from huge trees, so large, indeed, that the finished canoes were often from thirty to sixty feet in length. A canoe to seat three fishermen would be about thirty-three feet long, while a single-seated one was usually eighteen feet long by seventeen inches wide. Some of the canoes used sails, but as a general rule the paddle was the only motive power.

The seines were the most important part of the fisherman's outfit. These were frequently two or three hundred feet in length, and in certain cases they occasionally joined the long ones together. Their seines for catching bait were much smaller, usually only a few yards in length, with mesh as fine as quarter inch. Gill nets of different sizes and designs were also much used. They were used mostly at night and were commonly set across openings in the reef. Frequently these nets were laid out so as to enclose a large coral rock. The native fisherman would then dive down and drive the fish from the rock.

Another method sometimes used by the natives was to join several seines together and then paddle out to sea in a semicircle, paying out the seine as they went. The net would then be hauled in to shore and the last few yards

PLATE 86. THE SHARKS AND RAYS.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Hawaiian Cub-shark [Mano] (*Carcharias melanopterus*). 2. Thrasher Shark (*Alopias vulpes*). 3. Mackerel-shark (*Isuropsis glauca*). 4. Dog-shark (*Squalus mitsukurii*). 5. Hammer-headed Shark [Mano kihikihi] (*Sphyrna zygæna*). 6. Blue Shark (*Prionace glauca*). 7. Sting Ray (*Dasyatis hawaiiensis*). 8. Spotted Sting Ray [Hihimanu] (*Stoasodon narinari*).

of fine net brought together in a circular form. When advisable the fish thus caught might be left in the seine trap in the water for several days. Certain species of fish that run in school, as the akule, can be seen a considerable distance at sea. It is the practice among native fishermen to post one of their number on the land at an elevation from which their practiced eyes can locate the school of fish as it approaches the shore. In directing the operations of the fishermen from the shore, the lookout uses a white flag and observes considerable superstitious ceremony in his work.

Several forms of bag nets have been employed by the Hawaiians, some of them more than two hundred fathoms in length. The usually have detachable bags in the middle often thirty feet long by half as many feet in width. These were used in water twenty feet or more in depth. The opelu or bag nets are commonly about a dozen feet across by three times as deep, and have a hoop fastened in the mouth to keep the net open. In use they are baited and lowered, and then at the proper moment rapidly hauled in. Several ingenious nets are used in capturing various species of fish—the upena hehu, upena pua, kapuni nehu, upena uhu and the upena poo being important among them.

Several forms of dip nets were also devised by the Hawaiians. One was formed by tying two slender parallel sticks to a fine net about five feet apart. By running a string through the lower end and shirring it through the net, a rude bag was formed that was used in shallow water and for fishing in rough, stony places.

The Hawaiians seem to have used but few fish baskets, the two kinds used in catching the shrimp [1] being the most important forms.

Several species of fish were taken in fish-traps or pens. The group of shark pens removed from Pearl Harbor when the channel was dredged were among the best examples in the islands. They were so arranged that the fish, which enter them freely at high water, are caught as the water recedes, by means of a small seine.

Fish spearing was an art with the old Hawaiians, and they were very adept in the use of the weapon, which consisted usually of a long hardwood pole six or eight feet in length, ending in ancient times with one or two sharp wooden prongs, but in modern times, with a thin rod of iron, a foot or so in length, that is slightly barbed at the tip. This implement was only used in shallow water about the reef, where it might be employed in spearing squid, turtles, and other slow-moving surface-swimming forms. In the hands of an expert diver, however, it might be carried down into the water several feet and used with effect in caves and holes about the reef.

Fish Poison.

The natives were expert in making and using a certain fish poison known as holahola. A poisonous weed [2] which grows on the mountainside was col-

[1] Opae. [2] Ahuhu.

lected and pounded together with sand. The sand was used to make the mixture sink more readily to the bottom. With a quantity of this poison in the canoe the fisherman would search out a tide pool, cave, or hole in the reef inhabited by a number of species of fish. A long seine was first put out in a circle about the spot to prevent the fish from escaping. The poison mixture was then rolled in small packages or placed in a bag and carried down to the bottom by the fisherman in order to distribute it about to advantage in the holes in the rock. In ten or fifteen minutes the fish would come to the top in a stupefied condition, when they were easily gathered from the surface of the water. If allowed to remain too long in the water they would recover from the effects of the drug. When used as food they seem to be in no way injured by the poison used in their capture.

Fishing at Night.

A very picturesque method of fishing, much employed in former times by the natives, was by the light of the torch. At favorable seasons dozens of fishermen could be seen, each with a lighted fagot in one hand made of a bundle of ti leaves or a string of kukui nuts wrapped around with ti leaves to make a handle, and in the other a small net or spear. As the men and women waded about over the reef, the reflection in the shallow water from the flickering lights, together with the shadowy outline of the natives, their excited voices and weird, fantastic movements produced an impression on the mind of the spectator that time could not readily efface.

A method of fishing with a snare was perhaps peculiar to the Hawaiian Islands. This method was much employed in fishing for eel. It consisted in throwing the bait near a hole. In this way these greedy and unsuspecting animals were enticed through a wide noose which, attached through a loop, dangled from the end of a heavy pole. When the critical moment arrived the noose was hauled taut about the eel, and up snug against the end of the pole, by drawing in on the end of the line which passed along the pole to the hand.

Fishing with the hands was a common practice among the natives, but line fishing was more extensively followed and in general yielded better returns. Ingenious fishhooks made of mother-of-pearl shells were much used, though bone, ivory and tortoise-shell found an important place in the manufacture of these useful implements.

Fish Bait.

The selection of a suitable bait was by no means a simple task. While the live shrimp or opae was very frequently used, Mr. Joseph S. Emerson collected a list of no fewer than twenty-two compounded baits that were built up on a single base material. It is estimated that there were probably more than a hundred kinds of bait known to the skilled fisherman in ancient times in Hawaii. For line fishing, however, the live bait was preferred, and they had a method for catching the daily supply that will bear repeating among Hawaiian

fishermen of today. One man with a small calabash of dried shrimp was left on shore while the rest of the party took a seine with very fine mesh and paddled their canoes out a few yards from the shore. The man with the bait then walked along the beach a short distance, and after chewing up a few shrimp, would select a promising place and throw the morsal as far out to sea as possible. If small fish come up immediately the net was cast about the spot and a draw made in which all hands participated. If the bait was unmolested new bait was prepared and thrown out as before at what appeared to be a more favorable place. By this little trick, the fisherman was saved not only the time employed in making unprofitable hauls, but the chagrin of finding nothing, not even bait in his net, when it was landed.

Shark Fishing in Ancient Times.

In the capture of shark the ancient Hawaiians, especially the chiefs and alii, found much sport—and since the use of human flesh as bait was in great vogue among them, the method then employed is of more than ordinary interest to us; of course, the flesh of other animals has been substituted in these latter days.

The human body used was usually that of a slave, or at least some one out of standing with the royal fishermen. The person to serve as bait was killed two or three days in advance of the anticipated fishing expedition. The flesh of the victim was then cut up, placed in a container and left exposed to the air to decompose.

With the bait loaded on the outrigger of the canoe in such a manner as to admit of its leaving a dripping trail of blood and oil on the surface of the water, the fishing party would row their canoes out to where sharks were plentiful. Large bone or wooden hooks, some of them a foot long, were baited with the tempting morsels and lowered to the eager prey. Great skill and courage was shown by the members of the royal party on such occasions in roping and landing the captured shark.

Every part of the bone and skin of one of these savage animals was supposed to confer unflinching bravery on its possessor. For this reason Kamehameha I. was especially proud and jealous of his title as the great shark-fisher. He kept his victims penned up near the great heiau[3] of Mookini, near Kawaihae, Hawaii, so there was always a supply of bait on hand.

In the olden times the capture of a shark was really a great event, but it has been more than one hundred years since the last human being was made to figure in the preliminary plans of a day's aquatic sport. However, shark fishing is indulged in as a sport today, but the motor boat, the flesh of a horse for bait, and the use of rifles has done much to dull the heroic setting shark fishing must have had in days that are gone.

While the Hawaiians recognized but five species of sharks and gave to

[3] Temple.

PLATE 87. FISHING SCENES IN HAWAII.

(For Description of Plate See Opposite Page.)

each a characteristic name, there are as many as sixteen species belonging to a dozen genera that have been taken by scientific fishermen from the waters about the islands.

Man-Eater Sharks.

Of this number the larger species are usually spoken of as man-eater sharks, or tiger sharks. The real man-eater is a great white shark sometimes thirty feet in length. It is by all odds the most ferocious of all fish-like animals. Specimens have been taken in Europe, Japan, California, Hawaii and the Carolinas indicating that they encircle the globe. While but one species of this genus,[4] known as nuihi by the natives, is alive today, the teeth and certain other bones of extinct species that lived in former times, have been dredged from the sea bottom in the Mid-Pacific. Some of the other living species are really quite voracious, but that they are really man-eaters in the sense of pursuing, capturing and devouring the living body of a man is doubted by those who have given time and attention to the verification of the various shark stories that are current in Hawaii, as well as in all seaport towns.

Sharks with mouths twenty inches across, that are crammed with triangular teeth an inch or more in length, are not uncommonly captured about the islands. Since the number and size of the teeth is said to be directly in proportion to the ferocity of the shark, the larger species are to be studiously avoided, be they living or dead, even though we are continually reassured that they are not dangerous—as an incident taken from my note-book will demonstrate.

Several years ago I was on board a four-masted sailing vessel bound for Laysan Island, when our good ship became hopelessly becalmed. We had on board a party of Japanese laborers to be employed in the guano business on the island. To pass the time, and in response to an ancient and honorable superstition of the sea, all hands fell to fishing for sharks—since, as everyone who has sailed with canvas knows, the catching of a shark by a becalmed mariner has never failed to bring a fair wind. As all winds that blow for becalmed seamen are classed as fair, we were not surprised, within an hour after our crew had succeeded in hooking and loading an eight-foot shark, to find our vessel under headway again. As the Japanese are fond of shark stew, they were granted permission to make an open fire on deck and dress and cook the slimy savage token of our good luck.

An hour later one of the laborers commenced to clean the deck of the blood

[4] *Carcharodon carcharias.*

Description of Plate.

1. Shark fishing as practiced for the sport of the chase. 2. Catching skip-jacks [Aku] or Ocean Boneto from the jib-boom of a sailing vessel. 3. Five minutes' catch from the jib-boom. 4. Hawaiian spearing fish with a double pronged spear [kao]. 5. Fisherman with a throw net. 6. Man-eater Shark [Niuhu] (*Carcharodon carcharias*) captured off Pearl Harbor. This shark is the most voracious of all the fishes. 7. Natives fishing at Kahana Bay with long sea net [upena kuu]. 8. Large dip-net for reef fishing.

and offal left by the butchers. The ghastly head with its gaping mouth was first to be dropped overboard. Thrusting one hand for want of a better hold into the open mouth of the dead animal, the laborer slipped his other hand under the head as it had been cut free from the body, when, without warning, the yawning mouth clapped shut in a death grip on the hand and wrist of the Japanese. The suffering man was only extricated from the vice-like jaws by main strength. One of his comrades seizing him, another the shark's head, his hand was literally pulled, in a frightfully lacerated condition, from the dead animal's mouth. In spite of the fact that the animal's flesh had been boiling an hour, and was ready to be served to the waiting company of Japanese, the muscles of the jaws had responded to some stimulus that caused them to clamp the man's hand.

Sometimes the natives hunt for sharks in pools and caves in the reef, where they are occasionally found fast asleep. When a "shark hole" is located a diver will go down and deftly slip a noose about the tail of a shark, which is then hauled up and dispatched. Experts have captured six or eight fair-sized sharks in a day in this manner.

The skin of sharks in the hands of the natives found its principal use in the manufacture of heads for their hula drums, while the teeth and bones were used as ornaments and implements. The flesh was generally eaten, but out of respect to the great shark god it was tabu to women, who were forbidden to partake of it under pain of death.

The Hammer-Head Shark.

Among the various species of sharks the hammer-head,[5] or mano kihikihi, is perhaps most curious in its characteristics. It is a wide-ranging form found from the Mediterranean to Cape Cod in the Atlantic, as well as at widely-scattered localities in the Pacific, including Hawaii. The singular form of the head is one of the most unusual modifications among fishes. Instead of retaining the usual form, the front part of the head of these sharks is broad, flattened and extended on each side into a process, on the flat terminal surfaces of which are situated the eyes.

The Dogfish.

The Hawaiian dogfish,[6] which is also found in Japan, is an active species of the smaller sharks that may be identified by the stout spine in the dorsal fins and by their sharp, squarish cutting teeth. In the Atlantic, dogfish are sometimes captured in large numbers, their livers being used for the production of shark-oil. In Hawaii shark oil fishing has never been carried on to any extent, though sharks are abundant in certain localities, and once or twice vessels have been fitted out to engage in the trade.

The Mackerel Shark and "Killer" Whale.

Mackerel-sharks seven to nine feet in length which furnish the large

[5] *Sphyrna zygaena*. [6] *Squalus mitsukurii*.

jaws commonly seen preserved as curiosities in Hawaii, and the thrasher-sharks, are found about the group. The latter, sometimes attaining a length of twenty feet, may be identified at once by the great length of its cycle-shaped tail-fin. They are not especially ferocious, and the current stories of their attacking whales doubtless arise from mistaking the Orca for this shark. The Orca, or killer, is not a shark at all, but is a mammal belonging to the order of whales and is allied to the porpoise. As a passenger between Honolulu and San Francisco I once saw a number of them attack a school of whales. From the deck of the steamer we could see them clinging with their strong teeth about the heads and mouths of the great animals. The whales, panic-stricken, would leap clear out of the water, producing a terrific splash in their efforts to free themselves from their pursuers. Often they would roll over and over in their frantic endeavors to escape. Occasionally they would dislodge one of their tormentors, and it would be sent whirling through the air, apparently enjoying the novel experience. As the battle was at close range and lasted for a quarter of an hour or more, I was able to satisfy myself as to the identity of the combatants.

Rays and Skates.

Three families of rays or skates are represented in Hawaii by five well-defined species. Though differing widely from the sharks in form, they are related to them, and belong to the same sub-class of the great group of fish-like vertebrates. Three species of sting-rays have so far been taken from Hawaiian waters. These flat, disk-like animals have very long, slender, whip-like tails that are without typical fins, but in lieu of fins the tail is provided with a strong, jagged spine covered with slime. The mouth is armed with broad saw-like teeth. The spine inflicts a dangerous wound, not through the presence of any specific venom, but from the danger of blood poison arising from the slime and the ragged and unclean cut. Specimens six to eight feet in length are not uncommon in Hawaii. They may be distinguished from the eagle-rays or spotted sting-ray [7] by the fact that with the former the fin on the side of the disk extends forward on both sides to form the tips of the snout, while with the eagle-ray the muzzle is entire and free from the fin.

The Sea Devil.

The sea devil,[8] or hihimanu of the natives, is even more terrible in appearance than the sharks and rays, and is characterized by resembling the latter, but the anterior lobes of the pectoral fins are developed so as to stand up like horns or ears on the head. They are by no means common about Hawaii, and as all the members of the three families belonging to this order are of little value as food, they are seldom seen at the markets in the islands. They differ from the sharks in that they frequent the sea bottom, where they feed principally on shell-fish, which they crush with their flat teeth.

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[7] *Stoasodon narinari.* [8] *Mobula japonica.*

CHAPTER XXVII.

HAWAIIAN FISHES: PART TWO.

The scope of this brief account of the fishes of Hawaii will not permit of more than passing notice of some of the more interesting, curious, valuable or common species. It is left for those who are especially interested in the subject to either fish for themselves or to visit the Honolulu Aquarium, the market, or the Bishop Museum, where extensive collections offer opportunity for an exhaustive study.

Food Fish in the Markets.

Some idea of the fish resources of Hawaii can be gained from the fact that of the six hundred or more species that scientists have found in the island waters, more than three hundred and fifty are sold in the markets of Honolulu for food, each species having a Hawaiian name by which it is usually designated. Often several dozen species may be seen in the market in a single day—a fact which adds not a little to the confusion and difficulty of the inexperienced person when attempting to select a choice specimen for table use from the many fish of various sizes, shapes and colors.

Unfortunately, though the number of species to select from is very large, (as is usual with animals in warm countries) the number of individuals of any one species is not liable to be so plentiful in the tropics as in the colder climates. As a result fish are not as abundant nor as cheap in the markets as one could wish, where sea food should form the basis of a wholesome and cheap diet.

As many species run in schools and are liable at times to be very abundant and cheap at certain seasons and entirely wanting at others, it behooves the prudent housewife to be able to take advantage of bargains at the market as well as in the shops and stores.

For the benefit of those who may care to vary their fish order for one reason or another, the writer has secured, through the coöperation of a number of friends interested in the culinary side of the problem, the accompanying list[1] of especially useful food fishes, all of which are worthy of trial in any home. All of the long list of fish offered for sale are wholesome; the brief list appended serves simply as a suggestion and is offered with the view of encouraging readers to explore further on their own account. It will be noted that twenty species are enumerated which are used by all nationalities, which are regarded as the favorite fish of Europeans in the islands. Other columns show the various fishes used by the several principal nationalities visiting the Honolulu market. As an aid in identifying the choicest food fish, fourteen species are figured together on a single plate.

IMPORTANT HAWAIIAN FOOD FISH.

[1] A list of sixty-five of the more important food fish found in the Honolulu market, showing the species preferred by the various nationalities in the city is shown in the following table. The culinary uses made of twenty of the species most frequently purchased by Europeans is also shown, by the following designation marks placed after the native name, i. e., * = baking; † = boiling; ‡ = pan fish.

(Continued on opposite page.)

IMPORTANT HAWAIIAN FOOD FISH (See note on opposite page).

Native Name.	Scientific Name.	All races, especially Europeans	Hawaiians	Portuguese	Chinese	Japanese
Ahaaha	*Tylosurus giganteus*				X	
Ahi	*Germo germo*					X
Aholehole	*Kuhlia malo*		X		X	X
Aku	*Gymnosarda pelamis*		X			X
Akule * † ‡	*Trachurops crumenopthalma*	X	X	X	X	X
Aleihi lakea	*Pseudocheilinus octotænia*		X			
Ama-ama * † ‡	*Mugil cephalus*	X	X	X	X	X
A'a	*Xiphias gladius*		X			
Awa	*Chanos chanos*		X			X
Aweoweo	*Priacanthus cruentatus*		X			
Hapu'u pu'u * † ‡	*Epinephelus quernus*	X	X	X	X	X
Hihimanu	*Mobula japonica*				X	X
Hilu	*Anampses cuvier*			X		X
Hinalea lauwili	*Thalassoma duperrey*		X			
Humuhumu nukunuku apua'a	*Balistapus aculeatus*		X			X
Iheihe	*Hemiramphus depauperatus*		X			
Kahala * † ‡	*Seriola purpurascens*	X	X	X	X	X
Kaku	*Sphyræna snodgrassi*				X	
Kala	*Acanthurus unicornis*		X			
Kawakawa	*Gymnosarda alletterata*		X			
Kawelea	*Trachinocephalus myops*		X			X
Kikakapu	*Chætodon lunula*		X			X
Kumu * † ‡	*Pseudupeneus porphyreus*	X	X	X	X	X
Kupipi	*Abudefduf sordidus*		X			
Kupoupou	*Cheilio inermis*		X			
Lae ‡	*Scomberoides tolooparah*	X	X	X	X	X
Lauia ‡	*Callyodon lauia*	X	X	X	X	X
Mahihi * † ‡	*Coryphæna hippurus*	X	X	X	X	X
Maii'i	*Hepatus elongatus*		X			
Makiawa	*Etrumeus micropus*			X		
Malolo	*Parexocoetus brachypterus*; *Exocoetus volitans*; *Cypsilurus simus*		X			
Mamamo	*Monotaxis grandoculis*		X		X	
Manini ‡	*Hepatus sandvicensis*	X	X	X	X	X
Mano	*Squalus mitsukurii*		X			
Moi * † ‡	*Polydactylus sexfilis*	X	X	X	X	X
Mu	*Monotaxis grandoculis*		X		X	
Nehu	*Anchovia purpurea*		X		X	X
Ohua	*Cantherines sandwichiensis*		X			
Oio	*Albula vulpes*		X			
Omaka	*Stethojulis axillaris*		X			X
Omilu * † ‡	*Carangus melampygus*	X	X	X	X	X
Ono	*Acanthocybium solandri*					X
Oopu ‡	*Eleotris sandwicensis*		X		X	
Oopuhue	*Chilomycterus affinis*		X			
Oopukai	*Cirrhitus marmoratus*		X			
Opakapaka * † ‡	*Apsilus microdon*; *Bowersia violescens*	X X	X X	X X	X X	X X
Opelu palahu ‡	*Scomber japonicus*	X	X	X	X	X
Opelu	*Scomber*		X	X		X
Opule	*Anampses cuvier*		X			
Pakii ‡	*Platophrys pantherinus*	X	X	X	X	X
Pakuikui	*Hepatus achilles*		X			
Palawi	*Hepatus dussumieri*		X	X		
Papiopio ‡	*Carangus* (small size)	X	X	X	X	X
Poopa'a	*Paracirrhites cinctus*				X	X
Pualu	*Hepatus dussumieri*		X	X		
Puhi	*Gymnothorax* (a generic name for eels)		X	X		
Puhiki'i	*Parexocoetus brachypterus*		X			
Uhu	*Callyodon mineatus*		X		X	
Uku * † ‡	*Aprion virescens*	X	X	X	X	X
Ulae	*Saurida gracilis*		X		X	
Ulaula * † ‡	*Etelis marshi*	X	X	X	X	X
Ulua * † ‡	*Carangus* (large size)	X	X	X	X	X
Ulua kihikihi	*Alectis ciliaris*		X			
U'u ‡	*Myripristis murdjan*	X	X	X	X	X
Walu	*Hepatus xanthopterus*		X		X	
Weke ula ‡	*Mulloides auriflamma*	X	X	X	X	X

PLATE 88. EELS AND OTHER CURIOUSLY SHAPED FISHES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Bone-fish [Oio] (*Albula vulpes*). 2. Milk-fish [Awa] (*Chanos chanos*). 3. Hawaiian Herring [Makiawa] (*Etrumeus micropus*). 4. Anchovie [Nehu] (*Anchovia purpurea*). 5.

(Description of Plate Continued on the Opposite Page.)

Students of the subject of fish and fish culture tell us that there are now known in the waters of the world more than ten thousand species of bony fishes. These they have divided into about twenty orders, which are again divided into numerous families, and still more numerous genera. Of the important genera, a surprising number are represented in the fish fauna of Hawaii by one or more species.

Many of the six hundred or more species attributed to Hawaii are never seen in the markets, since they dwell only in the dark abysses of the deep open ocean, often miles below its surface. They are only captured by the use of complicated apparatus operated at great expense by scientific men commissioned to study the wonders of the great ocean, and who for their work must employ specially equipped vessels, such as the United States Fish Commission ship Albatross.

Then again, fish, like birds and plants and insects, have their peculiar habitats, and require special conditions or certain kinds of food. As a result, many of the common kinds are confined in very limited localities. Out of over one hundred species of food fish that are regarded as abundant in Hawaii, only five—the aku, oio, uku, ulaula and ulua—enter into the records as being taken commercially by the fishermen on all of the large islands of the group.

Of the large number of species of fish sold in Honolulu, almost none are the same species as are sold in the markets of the mainland or in foreign countries. This is because the fish fauna of Hawaii is isolated from that of other lands. However, most of the common families of sea fish have local representatives, some of them perhaps excelling in flavor the species with which strangers from abroad are more familiar. While in general it may be said that the fish fauna of Hawaii is in a large measure derived from the fauna of the East Indies, and while it is more closely related to the fishes of Polynesia than to those of North America or Japan, it should be regarded as constituting a minor faunal group composed in the main of forms which have been isolated long enough, in most instances, to form distinct species.

Anchovies and Barracudas.

A good example of this localization of species is shown by the nehu,[2] which is in reality a very abundant local species belonging to the genus including the widely and favorably known anchovy of commerce. So far they have only been secured from the Hawaiian Islands. They are fish of small size with a well-marked, broad, silvery lateral band. In 1900 the records for the islands shows a catch of more than ninety thousand pounds of this species for the year.

[2] *Anchovia purpurea.*

(Description of Plate Continued from Opposite Page.)

Lizard-fish [Kawelea] (*Trachinocephalus myops*). 6. Lizard-fish [Ulae] (*Synodus varius*). 7. Moray [Puhi] (*Gymnothorax ercodes*). 8. Moray [Puhi laumili] (*Gymnothorax undutatus*). 9. Moray [Puhi] (*Gymnothorax petelli*). 10. Moray [Puhi kapa] (*Echidna nebulosa*). 11. Trumpet-fish [Nunu] (*Aulostomus valentini*). 12. Sea-horse (*Hippocampus fisheri*). 13. Needle-fish [Ahaaha] (*Athlennes hians*). 14. Half-beak [Me'e me'e] (*Hemiramphus depauperatus*). 15. Half-beak [Iheihe] (*Euleptorhampus longirostris*).

PLATE 89. FISHING IN HILO BAY.

The photograph shows one of the remarkable cloud effects for which the islands are noted.

The family of barracudas [3] has two local forms, one of which, the kawelea[4] is not uncommon, as it frequents the mullet ponds along the shore. They seldom attain a length of more than twenty-four inches, and are therefore but feeble representatives of the great barracuda, that excellent food fish along the California coast, which is often five feet or more in length. Our local form is voracious and destructive to mullet, and do much damage to seines with their strong teeth which are set in a large mouth—two characteristics that are useful to the novice in separating them from the more valuable mullet with which they frequently occur.

Butterfly-Fish.

No one who has visited the Aquarium will need to be reminded that Hawaii can boast of a long list of beautiful creatures that might well be called the butterflies of the coral reefs.

Their compressed bodies, small size, continuous dorsal fins, small mouths, and brilliant, varied and beautiful colors are characteristics sufficient to distinguish them at once from their near relatives under a family name, *Chætodontidæ*, which has reference to their distinctly brush-like teeth. The five genera found in Hawaii embrace at present about eighteen species that, owing to graceful form, bright colors and great activity, make them exceedingly popular as aquarium specimens. Their great quickness and agility enable them to maintain themselves in the struggle for existence in the close competition of the coral reef, in spite of their conspicuous habits and coloring. In the typical genus [5] a black band usually crosses through the eye; kikakapu is the native name applied to several well-marked species which vary so widely in their colors as to defy brief description.

Blennies.

Representatives of the family known as Blennies [6] are certain to be noticed by the most casual observer strolling along the beach. The little fish most commonly seen clinging to the coral rocks as the waves recede is one or another of the nine or ten species of this family. They are active and alert, and since there are in the world more than five hundred species, many of which never attain a length of two inches, it is not strange that the naturalist seldom ventures to name, off-hand, the various examples that so often form the sum total of the catch secured by a wading party. However, it may be well to know that *Enneapterygius atriceps* is the only name given the little fish with the large eyes, three dorsal fins and the whip-like pectorals that is common in the coral rocks about Honolulu.

The Hawaiians did not distinguish it as separate from its relatives. Of its next of kin two or three species of the genus *Alticus* are also quite common about the islands; they have two dorsal fins. The small dark olive *Salaris zebra* is the most abundant species. It has the body crossed by numerous alternating pale and dark-olive bands, and has a curious lash above the eye.

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[3] *Sphyrænidæ.* [4] *Trachinocephalus myops.* [5] *Chætodon.* [6] *Blenniidæ.*

Bone-Fish, Catalufas and Cirrhitidæ.

The bone-fish, or lady-fish,[7] have a single representative in Hawaii known as the oio.[8] It is a silvery fish with soft flesh that resembles the milk-fish in some respects, but is distinguished by its swine-like snout.

The Catalufas[9] are represented by but a single genus of three species. One of these, the aweoweo,[10] is the famous "red fish" which during the month of September, 1873, entered Honolulu harbor in shoals. They were evidently young fish, as the largest were not more than three and a half inches long. This shoaling has occurred from time to time at irregular intervals. In the mind of the native the coming of the red fish presages the sickness and death of some member of the royal family. On several occasions there has been a singular sequence of events of this nature which has left its impress on the beliefs of the more superstitious among the people. The fish are esteemed as food by the natives, however, who regard their coming in large numbers in the nature of a windfall, as the fish can be readily dried and saved. The species is of wide distribution and among English-speaking people is known as the "big eye."

The family *Cirrhitidæ* includes among its number seven of the more beautiful and highly-colored fishes of the coral reef, and as they are almost constantly to be seen in the market and at the Aquarium, the pilikoa,[11] hilu pilikoa[12] and piliko 'a[13] are well known, though they are seldom more than six inches in length.

Deep-Sea Fishes.

The fishes of the deep sea are for the most part examples of the familiar forms that have become modified and specialized to suit the peculiar environment of great pressure, inky blackness and freezing cold which the bottom of the sea affords. Eels, soles, scorpion fish, box fish and dozens of other forms found commonly on our shores have their deep-sea representatives that are seldom seen by other than experts to whom are sent the rare examples, secured at great cost and labor by scientific deep-sea expeditions. We therefore content ourselves with the knowledge that they exist and confine our attention to the more common, if not the more interesting, species that are met with in the markets almost daily.

The Dolphin.

The dolphin[14] (mahihi) is an important food fish in Hawaii. The body is elongate, compressed and covered with very fine scales. The under jaw protrudes and the long low dorsal fin extends from the nape to the base of the tail. It is changeable in color and thus becomes a conspicuous fish either living or dead, but unfortunately its beautiful color rapidly changes after death. They attain the length of four to six feet.

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[7] *Albulidæ.* [8] *Albula vulpes.* [9] *Priacanthidæ.* [10] *Priacanthus cruentatus.*
[11] *Paracirrhites* spp. [12] *P. fosteri.* [13] *P. arcatus.* [14] *Coryphæna hippurus.*

Both known species of dolphins occur in Hawaii. As they are very large fish of the open sea and are surface swimmers, they are occasionally seen by passengers on board sailing vessels. While the name dolphin rightly belongs to a group of small whales, it has been associated with this fish. In song and story their beauty of color and grace of motion have received much attention.

Eels.

The order *Apodes*, which includes the eels and morays is well represented in Hawaii, several dozen species frequenting the coral reefs and rocky coasts. Eel-fishing is a favorite sport, as the animals are easily enticed from their hiding places in the rocks, when they may be hooked or speared.

The Hawaiian name puhi is applied to the class as a whole. Puhi-uha signifies slippery eel, and is applied to the conger-eel. Some of the larger examples attain a length of five or six feet, and are much sought after as food.

Frog-Fish and Flying-Fish.

Two genera of frog-fishes[15] occur, but representatives of only one genus have so far been taken in the shallow water or open sea. They all have the head compressed, and the skin covered with prickles, the body oblong and much compressed. They are fantastic-looking fishes, often gaily colored, and feed among the seaweeds on the reef, where they creep about like toads. They are also capable of filling their capacious stomachs with air, which enables them to float on the surface of the water. Eight species occur on the reefs, all of which are provided with one or two whip-like lashes that protrude from the upper lip to form a "bait" over their cavernous mouths.

Flying-fish[16] abound in the open sea in all tropical waters, and Hawaii's waters are in no way an exception. Five well-marked genera include the eight species, all of which are called malolo by the natives. They are most abundant during the summer months. A common species[17] has the upper part of the body dark blue and the fins about two-thirds the length of the body. They, in common with their cousins, usually occur in shoals, and are a source of interest to the voyager as they leap from the surface of the sea and sail away, sometimes sustaining a so-called flight for a hundred yards or more. The most recent sport in Hawaii is flying-fish shooting. This is done from a power launch, as the fish skim over the water. The fish are a favorite food of the natives, who prefer to eat them raw at their feasts (aha-aina).

Gobies.

Gobies[18] have no near relatives among the spiny-rayed fishes, and as a family may be easily recognized. The ventral fins are inserted very close together; there is no lateral line and no bony stay to the preopercle, which gives to the gills a peculiar flabby appearance. The species are very numerous in the tropics, there being fourteen genera in Hawaii, usually with but one or

[15] *Antennariidæ.* [16] *Exocoetidæ.* [17] *Parexocoetus brachypterus.* [18] *Gobiidæ.*

PLATE 90. FISHES AT THE AQUARIUM.

1, 2, 3, 4. Taken by the use of the special photographic aquarium and reflection hood shown in fig. 6 (apparatus devised by the author). 5. View of Honolulu Aquarium at Waikiki.

two species each. This fact indicates the diversity of form found in the family. They inhabit mountain streams and brackish water, and are common in pools along the shore and in shallow water generally, but they never go far out to sea. The largest species rarely exceed eight or ten inches in length, while many of the small forms are only an inch or so long when full grown.

Oopu, in combination with specific terms, is the name applied by the Hawaiians to a great number of species of gobies. They are carnivorous in habit, and are exceedingly interesting and active little creatures. One of the common forms [19] is a dirty-brown color throughout and attains a length of nine inches. They somewhat resemble the common catfish in shape and color, and are plentiful in fresh brackish and shallow water. The natives often capture them in large numbers from the streams by the use of the fish poison previously referred to. The practice is to divert the stream from its usual course so as to leave a series of small shallow pools along its bed. The poison is then freely used in the crevices and under stones where the oopu hide. In a few minutes the fish come to the surface in a stupefied condition, when the native fishermen, both old and young, join in gathering them into their baskets and calabashes.

A species known as *Eviota epiphanes* is a very small oopu common in the shallow water at Waikiki. It attains the length of about three-fourths of an inch. Another abundant and wide ranging species of oopu is *Mapo fuscus*, which is very dark in color with black marblings and brown edges to the scales.

A curious oopu [20] is dark greenish-olive with the back and upper parts crossed with fourteen black bars. They have the pectorals united to form a curious disk on the chest. This species is abundant in certain Hawaiian mountain streams, and is able to cling to the rock in the rush of the mountain torrent. They are strictly a fresh-water fish, attaining the length of five to seven inches, and are sometimes caught and used for food. Two closely-related oopus [21] are common in fresh-water streams of the islands and are taken in numbers sufficient to make them common objects in the Honolulu markets. One species [22] is olivaceous in color, crossed with a dozen black bars. It has a black patch below the eye, and its belly is red while its cousin [23] is olivaceous, marked with obscure dusky blotches, and has the belly pale and with a dark blotch at the base of the tail.

The Flying-Gunard.

The flying-gunards [24] are striking fish resembling the common flying-fish in the very large wing-like pectoral fins, but differing from them in many respects, among others in having the head and body decidedly quadrangular in form and bony in structure, and by having two separate spines in front of the two dorsal fins. The tail fin ends squarely, while the tail in the flying-fish is always forked. The lolo-oau [25] is not very abundant, and as a result when a specimen appears in the market it is an object of considerable curiosity. Speci-

[19] *Eleotris sandwicensis.* [20] *Sicydium stimpsoni.* [21] *Awaous* spp. [22] *Awaous genivittatus.*
[23] *Awaous stamineus.* [24] *Cephalacanthidæ.* [25] *Cephalacanthus orientalis.*

mens fourteen inches in length are sometimes caught, and as their "wings" are almost as long as the body and are beautifully colored with blue and brownish-red, they are with reason pronounced by many as the most striking and fantastic of the Hawaiian fishes.

Headfish.

The headfish,[26] though much rarer, is equally striking and has been classed among the rarest and most wonderful of all animal forms. To the natives it is known as the apahu, or to some as the makua. It appears simply as a large head separated from the body and supplied with a fringed tail. They are fishes of the open sea and reach a very large size. As the flesh is coarse and tough, they are rarely brought into market except as curiosities. The cast of a very large specimen is on exhibition in the Bishop Museum. It shows the beautiful coloring of brown and silver of the living fish.

The headfish is known to the Hawaiian fisherman as the "king of all the mackerel," and as it is supposed to be under the rule of the spirits,[27] it is feared that the mackerel will disappear if the fish is killed. A similar fish in the Atlantic is known as the king of the herring, and the local superstition is doubtless colored by the influence of the early whalers and traders that called at the islands.

Curious fish known as the half-bills[28] are very common in the markets, where all three of the species that occur here may be recognized at once by the fact that the under jaw is singularly bill-shaped, while the upper jaw is normal. Of the three species, the iheihe or me-me'e[29] is the most abundant They are oviparous fishes and feed on green algæ. The half-bills live in large schools, usually near shore, and are especially numerous in the channels about the islands.

Hawaiian Herring.

The makiawa,[30] so far as is known, is the only representative of the great herring tribe[31] to be found about Hawaii. It attains a length of about ten inches and is quite common in the market at certain seasons. It is easily identified by its herring-like shape and appearance.

The family *Kuhliidæ* is conspicuously represented in Hawaii by the aholehole,[32] a silvery, fish-shaped fish, with the edge of the first dorsal and the caudal fins narrowly edged with black. They attain a length of ten inches or more. This active fish is sure to attract notice, since it is common at the mouths of the Hawaiian streams in both brackish and fresh water, but dwells by preference in running water, where it may be found in the deeper pools. It is a good fish and takes the hook readily, resembling the fresh-water sun-fish of America in this regard. The natives sometimes capture them by use of the narcotic plant described elsewhere.

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[26] *Ranzania makua.* [27] Akua. [28] *Hemiramphidæ.* [29] *Hemiramphus depauperatus.*
[30] *Etrumeus micropus.* [31] *Clupeidæ.* [32] *Kuhlia malo.*

The Wrasse-Fishes.

The *Labridæ* or wrasse-fish—a New England name—includes more than twenty genera in which are distributed more than fifty Hawaiian species. Of this large family only a few examples can be mentioned. The general form of the various species, though it varies somewhat from one genus to another, is sufficiently characteristic throughout the family to render them easily identified as members of the same division. The color patterns, usually of the brightest hues of blue, green, golden, scarlet, crimson and purple, are as rich and deep as though laid on with a brush by a most lavish hand. Often, in addition to its vivid color, the pattern is one of the greatest delicacy or the most intricate design.

Most of the wrasse-fishes feed upon mollusks and have their teeth adapted for crushing shells, but as they frequent the rocky coast, the coral reefs, the kelp beds, and the open sea, their food must necessarily vary considerably. However, in all the genera the teeth in the front jaws are prominent, separate and pointed.

Perhaps the most brilliant species are among those in the genera *Thalassoma* and *Julis*, but the more delicately-colored species are among the *Stethojulis*. The a'awa,[33] omaka,[34] akilolo,[35] opule,[36] awela,[37] hinalea lauwili,[38] lolo and hilu[39] and poou [40] are among the species to be seen almost daily in the markets, and often in the Aquarium.

The lantern-fishes and lizard-fishes [42] are well represented in the Hawaiian fauna, the kawelea [43] and ulae [44] being common examples of the latter. Their large mouths and lizard-like shapes render them easy of identification in the markets. The lantern-fishes are for the most part denizens of the deep, and as they live away from the shores, they are seldom seen except when they come to the surface at night or in times of stormy weather.

Mullet.

The mullet is by far the most important and generally esteemed food fish of the islands. There are three genera of the family,[45] each represented by a single species that have been reported from the group, but it is the species commonly called the ama-ama,[46] that is the most abundant. It is this species which in former times received the most attention from the natives in the way of protection and conservation. So much has been done along this line that mullet ponds have been important institutions since the days of the early chiefs. In fact, the time of the building of many of the ponds extends far back into the age of fable, the Hawaiians attributing the construction of one of the ponds on Kauai to the work of the menehunes—a fabled race of dwarfs that correspond in many ways with our Brownies.

Many of the oldest mullet ponds are still in use and in an excellent state of repair. As the ponds were originally owned by the kings and chiefs, it is

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[33] *Lepidaploia* spp. [34] *Stethojulis* sp. [35] *Gomphosus* sp. [36] *Anampses* sp. [37] *Thalassoma* sp.
[38] *Thalassoma* sp. [39] *Julis* spp. [40] *Cheilinus* sp. [41] *Myctophidæ*. [42] *Synodontidæ*.
[43] *Trachinocephalus myops*. [44] *Synodus varius*. [45] *Mugilidæ*. [46] *Mugil cephalus*.

very probable that most of them were built by the forced labor of the common people.

The ponds are found principally in the bays indenting the shores of the islands, the common method of construction having been to build a wall of lava rock across the narrowest part of the entrance to a small bay and use the enclosed space for a pond. They were also built on the seashore itself, the wall being built out from the shore in a half circle.

Ponds vary in size from small ones of less than an acre in extent to the unusually large one at Moanalua, on Oahu, which encloses over five hundred acres. There are as many as a hundred and sixty of these ponds indicated on the maps of the islands. Of this number perhaps one hundred are still in use. The catch of ama-ama from the ponds of the islands in 1905 was 430,000 pounds, valued at more than $87,000.

The mullet that find their way to the market from these ponds are identical with those found in the markets of the United States, Japan, Chile and even the Mediterranean and as far away as India. The average weight of the mullet in the market is from one to three pounds, though they grow to two or three times that size, attaining a length of twenty inches or two feet.

They feed on organic matter, especially the minute plants contained in the mud on the bottom in the shallow water along the shore. As they naturally gather up a large quantity of indigestible matter, these fishes have the organs of the throat modified into a filtering apparatus. They take in large quantities of mud and sand and, after apparently chewing it for a time, spit out the indigestible portion.

The awa [47] and the awa-aua [48] are also reared in large numbers with the mullet in the ponds. They all enter the ponds when young through openings left for the purpose in the stone walls. Owing to the protection furnished by the walls, the mullets thrive and fatten rapidly and, sheltered from their enemies, become stupid and blundering.

CHAPTER XXVIII.

HAWAIIAN FISHES: PART THREE.

Flatfish.

The visitor at the Aquarium is sure to be interested and delighted with the beautiful and graceful flatfish that, in general habits and appearance, resemble the butterfly-fish, but differ from them in having the dorsal fin drawn out to form a beautiful white plume-like filament often six inches or more in length. The species is known to the natives as kihikihi, but since it is a wide

[47] *Chanos chanos.* [48] *Elops saurus.*

ranging form they are known to Europeans generally as Moorish idols.[1] They are quite common about the Hawaiian reefs, where their yellow bodies crossed by broad black bands, and the long plume-like dorsal fin render them especially conspicuous even among their brilliant and beautiful associates.

Morays.

The morays[2] include an important group of Hawaiian fish that are distinguished from the true eels, with which they are closely related, by the presence of the small round gill openings and by the absence of pectoral fins. Many of the species reach a large size and are extremely voracious and pugnacious. As they are especially abundant in holes in the coral reefs and not infrequently spring out and bite the hand of even the experienced fisherman, it is just as well for the stranger to bear them in mind when on wading expeditions. Too often it has happened that underneath the most innocent looking flat coral stone exposed at low tide there has been hidden one of these snake-like fishes. If they choose to do so they can resent any intrusion from the merely curious in an unexpected and painful manner, that is long remembered by the offender.

Six genera of morays have so far been identified from the waters about the islands. Of the forty-two species of morays found here no fewer than eighteen belong to the genus *Gymnothorax*. The puhi laumili[3] is one of the most common as well as most savage of these. They are not infrequently taken with large fish in their stomachs, sometimes a fourth as long as the moray itself. It ranges in length up to three feet or more, is variously mottled and naturally is much feared by the natives.

One of the fiercest of all the eel tribe is the moray known as puhi kapa,[4] so called because it is said to be victorious over all kinds of fish. In life it is a pale greyish-white covered with irregular dark-brown areas with crome-yellow spots; the bars between these areas, when present, are gray and brown. It is reported by the natives that this eel goes ashore in the grass at night and will wiggle back into the water when disturbed.

The members of the order *Apodes*, to which the eel-like fishes belong, are very well represented in Hawaii, there being several dozen species, that usually differ one from the other only by slight characteristics. Most of the larger species are much used as food by the Hawaiians. The flesh of the morays, however, is oily and not readily digested and on the whole is not so wholesome as the flesh of the true eels.

The Mackerel Family.

Eight species of the mackerel family[5] occur in Hawaiian waters, including representatives of the frigate-mackerel, little tunnies, ocean bonito, Albacores and Petos. The opelu, or true mackerel,[6] the aku, or ocean bonito,[7] and the ahi,[8] all belong to different genera in the mackerel family. They all rove the sea, usually in large schools, and have a wide range. While they differ in outline considerably, in the different genera, they are all "mackerel-shaped" and are

[1] *Zanclidæ.* [2] *Murænidæ.* [3] *Gymnothorax undulatus.* [4] *Echidna nebulosa.*
[5] *Scombridæ.* [6] *Scomber japonicus.* [7] *Gymnosarda pelamis.* [8] *Germo germo.*

PLATE 91. CHOICE HAWAIIAN MARKET FISH.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Big-eyed Scad [Akule] (*Trachurops crumenophthalma*). 2. Mullet [Amaama] (*Mugil cephalus*). 3. Grouper [Hapuupuu] (*Epinephelus quernus*). 4. Amber Fish [Kahala]

(Description of Plate Continued on the Opposite Page.)

marked with two well developed dorsal fins which are followed by a series of little finlets; there is also a similar series of finlets posterior to the anal fin.

Though the flesh is usually coarse and dark, it is firm and oily. The opelu especially is much valued as food, two hundred and seventy-five thousand pounds of this species being marketed in Hawaii during the year 1903. The aku is very abundant about Hawaii, particularly in the summer, and quantities of them reach the market almost daily. There is a record of a yearly catch for the islands that approaches eight hundred thousand pounds. The ahi or albacore is known from its cousins by the bright yellow color of its finlets. Though not so abundant as the other species mentioned, it is frequently taken with a hook, and large specimens are occasionally seen in the markets.

The little tunny or kawakawa [9] is at once recognized as a mackerel, but differs from the ocean bonito [10] by its having the lateral line straight and with no blue-black stripes below the line. They swarm through the high seas in shoals, especially during the summer months, and are easily captured on an unbaited hook. The writer has caught them by the dozens from the jib-boom of a sailing vessel in mid-ocean. When drawn from the water they give one terrible death shudder and are "as dead as a mackerel" instantly. They are usually twenty inches long and weigh about three pounds when seen in the market; they are a fairly good food fish. In this connection it is of interest to note that so far as the records show, the California bonito has been taken in Hawaiian waters only once.

Milk-Fish.

The milk-fish [11] (awa) is a silvery fish that is largely used for food in Hawaii, notably about Honolulu, where a quarter of a million of pounds of the species is offered for sale in the markets annually. Next to the mullet, it is the species most frequenting the artificial ponds into which it runs with the mullet at high tide and is retained. Although it is an excellent food, it is not considered a game fish. Like the mullet it is known by different names at different ages, all of which are combinations of the name awa. They can be recognized at once since they have but one dorsal fin, while the mullet has two. Specimens five feet in length are not uncommon in the open sea.

Needle-Fish.

Three species of needle-fishes,[12] each belonging to a different genera, are

[9] *Gymnosarda pelamis.* [10] *Gymnosarda pelamis.* [11] *Chanos chnnos.* [12] *Belonidæ.*

(Description of Plate Continued from Opposite Page.)

(*Seriola purpurascens*). 5. Goat-fish [Kumu] (*Pseudupeneus porphyreus*). 6. Common Dolphin [Mahimahi] (*Coryphæna hippurus*). 7. Striped Surgeon Fish [Manini] (*Hepatus sandvicensis*). 8. Cavalla [Omilu] (*Carangoides ferdau*). 9. Snapper [Opakapaka] (*Bowersia violescens*). 10. Cavalla [Small = papiopio, medium size = Paupau, large = Ulua] (*Carangus ignobilis*). 11. Snapper [Ulaula] (*Etelis marshi*). 12. A Squirrel-fish [U-u] (*Myripristis berndti*). 13. A Snapper [Uku] (*Aprion virescens*). 14. Surmullet [Weke ula] (*Mulloides auriflamma*).

met with in the ocean about the islands. Their elongate, slender bodies with long beak-like jaws that are set with a band of small sharp teeth, besides a set of wide, sharp, conical teeth, together with the dorsal fin opposite the anal fin set far back on the body, are characteristics sufficient to separate them from the flying-fish on the one hand, and the half-bills on the other, as these two families are the only Hawaiian fish with which they would be confused. Superficially they resemble the common gar-pike. They are voracious, carniverous fishes that swim along the surface of the sea, often leaping from the water. Specimens four feet long occasionally reach the market, and are much sought after as food by certain races. Ahaaha,[13] as they are called by the Hawaiians, are common in the market every month of the year.

Pampanos.

Of the more than two thousand known species of pampanos,[14] at least twenty-five have been taken in Hawaiian waters. Their bodies are compressed, somewhat resembling the mackerels in form, but they are without the finlets which are so marked a characteristic in the family. As a rule, they are metallic-blue in color, varied with silver and gold, and have the lateral line in most cases armed with bony plates posteriorally. The simple mark of the family, however, is the presence of two separate spines in front of the anal fin. The *Carangidæ* are all rapid surface swimmers, so much so that occasionally the dorsal fin will be seen cutting through the surface of the water. They are all regarded as excellent fish, but the lae, puakahala, opelu, akule, apuu-u, and the ulua, and the curious ulua kihikihi or thread fin, are among the best known species. The ulua[15] is indeed one of the most important food fish of the islands. Specimens three and even four feet in length are common enough in the markets. It dries readily and the head is especially esteemed for use in the making of fish chowder. This species is considered by many to be the most delicate and finely flavored food fish to be taken in these waters and is quite generally substituted for mullet and opakapaka on the bill of fare of the most fastidious.

Tarpon.

The tarpon occurs in Hawaii and resembles the bonefish quite closely, but its dorsal fin is inserted well before the anal, a characteristic which separates its family[16] from the others of the order. It is said to be a great game fish in Florida, where it is common. Tarpon have little value as a commodity in the Hawaiian markets.

The thread-fin with the long threads, sometimes twice the length of the fish, trailing from the dorsal and anal fins is a curious fish of wide distribution that is occasionally seen in the markets, and is without doubt the most striking member of this family of pampanos,[17] a large family which includes local repre-

[13] *Athlennes hians.* [14] *Carangidæ.* [15] *Carangus ignobilis.* [16] *Elopidæ.* [17] *Carangidæ.*

sentatives of all such well-known forms as the pilot-fishes, amber-fishes, the runners, mackerel-scads, big-eyed scads and cavallas.

The Parrot-Fish Family.

The parrot-fish,[18] of which the islands can boast of a large assortment, resemble the wrasse-fishes[19] in color, form and scales, but differ in that they have the teeth more or less fused together which gives to the mouth a heavy beak-like appearance suggestive of the bill of a parrot. They are all herbivorous fishes, some of them attaining a very large side. They are abundant about the coral reefs where they always add a touch of vivid color to the wonderful picture to be seen through an observation hood or a glass-bottomed boat. The flesh is soft and white and of a rather pasty nature. It is a favorite fish with the Hawaiians, who eat it raw at their feasts, but it is seldom cooked by Europeans.

The color pattern of this group is greatly varied and the family is broken up into many species. In Hawaii four well-marked genera occur and at least two dozen species have been found and described from the islands. The ponuhunuhu[20] has the spinous dorsal fin with a distinct black spot between the first and second spines and the sides somewhat mottled, but without definite spots or specks. They are quite common in the markets. The uhu[21] is a general reddish color without conspicuous markings other than a narrow violet line on the outer edge of the dorsal. They are not very abundant and as a result command an exorbitant price. The uhu uliuli[22] is one of the handsomest fish of the islands. It is green in color with bars or stripes on the dorsal and spots on the scales of the lower sides and a curious rectangular patch over the snout. The blue parrot-fish[23] is a fine brilliant blue fish that in the olden time was tabu, for the use of the chiefs alone. It now sells at a ridiculously high price and is eaten raw. The pipe-fish family[24] is represented by three or four genera, one of which[25] is of interest since it includes two island species of the curious sea-horse. Both species are so rare, however, that there seems to be no generally accepted native name for the curious animal.

Porcupine-Fish.

Porcupine fishes[26] occur in the group, there being four species in all. They are more or less spherical in form and as the name implies, have the body well armed with sharp spines the bases of which are so broad as to form a coat of mail in the skin. The oopu kawa[27] is the species commonly on exhibition in the Aquarium. It is a sluggish fish, living at the bottom among the seaweeds on the coral reefs about the islands. They are reported as being poisonous. When disturbed they swallow air and float belly up on the water. Their power of inflation, however, is not so marked as that of the globe-fish or puffers, to which they are related. As they are seldom used for food, their principal use

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[18] *Scaridæ.* [19] *Labridæ.* [20] *Calotomus sandvicensis.* [21] *Callyodon miniatus.*
[22] *Callyodon perspicellatus.* [23] *Pseudoscorus jordani.* [24] *Syngnathidæ.* [25] *Hippocampus.*
[26] *Diodontidæ.* [27] *Diodon nudifrons.*

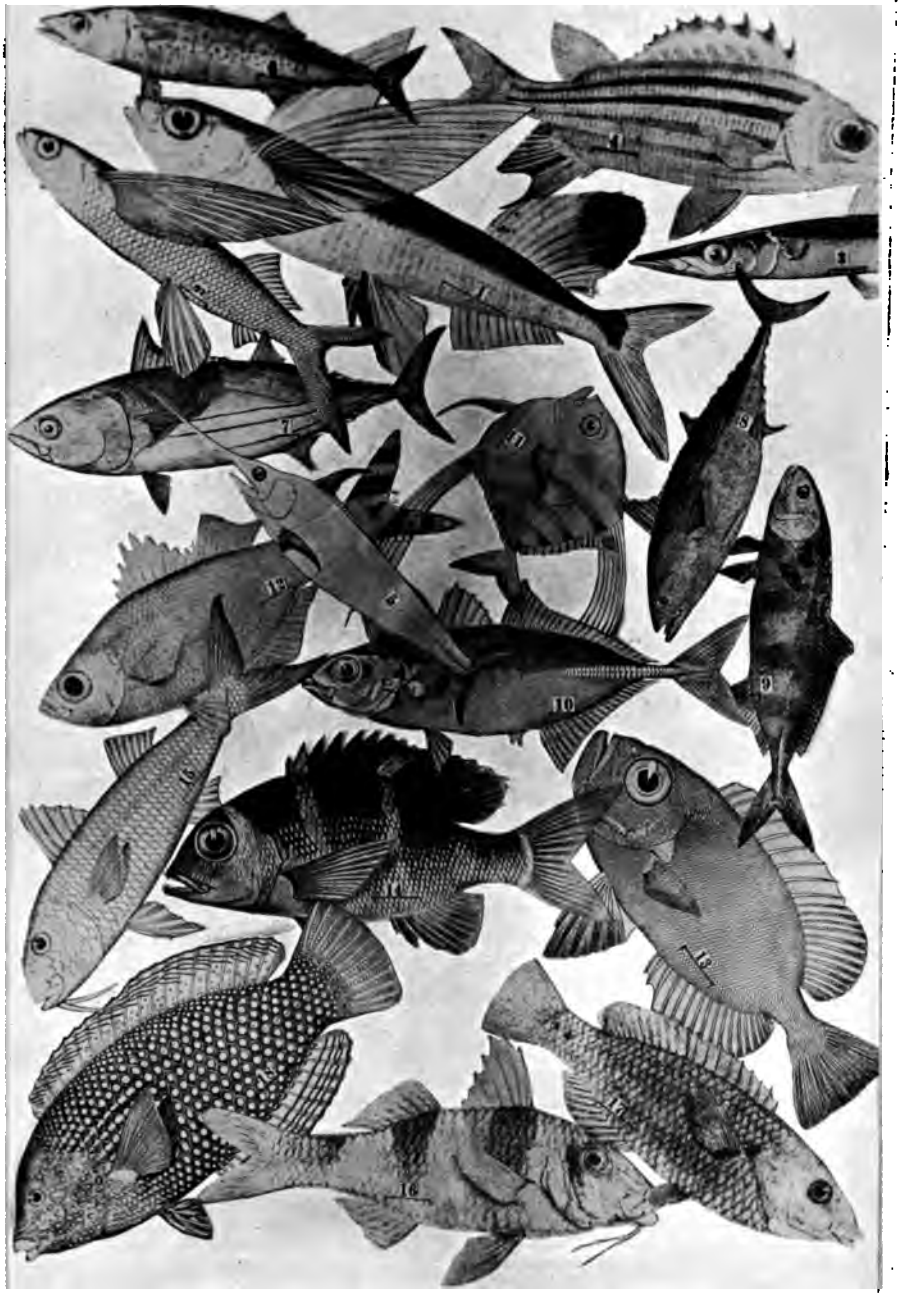

PLATE 92. CURIOUS AND COMMON HAWAIIAN FISHES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Flying Fish [Malolo] (*Parexocœtus brachypterus*). 2. Flying Fish [Malolo] (*Cypsilurus simus*). 3. Barracuda [Kawalea] (*Sphyræna helleri*). 4. A Squirrel Fish [Alaihi]

(Description of Plate Continued on the Opposite Page.)

is as curiosities, and they are objects of never-failing interest at the Aquarium and in natural history collections.

The name porgy was applied by the Greeks to a red fish of this family [28] common in the Mediterranean. Since then the name has been carried over the world by the Spanish and came to be the common name applied to a group of carniverous shore fishes of the tropics which are everywhere esteemed as food. The single Hawaiian porgy is the mu.[29] In their general shape they somewhat resemble the sea-snappers, having their bass-like mouth armed with several conical canine-like teeth in front. They are greenish in color with two paler cross-bands that extend up into the dorsal fin.

The Puffers.

The puffers [30] and sharp-nosed puffers [31] are two families, closely related to the porcupine fish, that have ten species belonging to four genera in the Hawaiian fauna. The walls of the abdomen are capable of distention so that when inflated the fish appears like an animated glass globe with a head and a tail attached. The oopuhue, or keke,[32] is the most abundant species. It is light olive-green covered over the back with pearly spots, the belly being striped with light yellow and pearly, but the colors vary greatly with age. It is an abundant fish in suitable places about Honolulu, where it frequents mullet ponds and brackish water generally. When removed from the water they swell up as tight as a drum and remain in this condition until returned to the water, where they will float on their backs in a helpless condition for some time; eventually they collapse and swim off. Cabinet specimens hardened in alcohol will remain in an inflated condition indefinitely. Specimens fourteen inches in length are common. The native name, meaning "sure death," indicates the Hawaiian belief in its poisonous character. The gall doubtless contains an active poison, said by some to have been used on spear-points. Puffers are seldom, if ever, seen in the markets, but are commonly captured in seines in the mullet ponds. They vary greatly in color with age, while in some the body is smooth and in others more or less covered with prickles.

The Remora.

The remoras, disk-heads or sucking-fish,[33] while not commonly met with

[28] *Sparidæ.* [29] *Monotaxis grandoculis.* [30] *Tetraodontidæ.* [31] *Canthigasteridæ.*
[32] *Tetraodon hispidus.* [33] *Echenididæ.*

(Description of Plate Continued from Opposite Page.)

(*Holocentrus microstomus*). 5. Swordfish. [A'u] (*Xiphias gladius*). 6. Mackerel [Opelu palahu] (*Scomber japonicus*). 7. Ocean Bonito [Aku] (*Gymnosarda pelamis*). 8. Little Tuna or Bonito [Kawakawa] (*Gymnosarda alletterata*). 9. Pilot Fish or Romero (*Naucrates ductor*). 10. A Cavalla [Puakahala] (*Carangus affinis*). 11. Thread Fish [Ulua kihikihi] (*Alectis ciliaris*). 12. Sea Perch [Aholehole] (*Kuhlia malo*). 13. Catalufa [Alalaua] (*Priacanthus alalaua*). 14. Porgie [Mu] (*Monotaxis grandoculis*). 15. A Surmullet [Weke ulaula] (*Mulloides flammeus*). 16. Goat-fish [Mumu] (*Pseudupeneus bifasciatus*). 17. A Wrasse Fish [Omaka] (*Stethojulis axillaris*). 18. A Wrasse Fish [Opule] (*Anampses curier*).

are so curious in form and habit that they are sure to attract attention when they occasionally come to market attached, barnacle-like, to the body of some shark, or turtle, or large fish. They are slender, violet-blackish colored fish that are peculiar in that they have the first dorsal fin transformed into a sucking disk, which covers the entire head and nape. The shark sucker [34] of Hawaii is one of two widely distributed species, but as they are neither very abundant nor used as food, their appearance in the markets is entirely owing to their interesting habits. By affixing themselves to their hosts they are carried through a much greater extent of water than their own limited swimming powers would admit. They obtain thereby a much greater supply of food than they would otherwise secure. They may be carried about for weeks by their hosts, leaving them only to secure food. This is done by a sudden rush through the water. The remora does not injure the carrier-animal in any way, and as they are of small size, rarely being more than six or eight inches in length, they do not materially impede the progress of their hosts.

The Scorpion-Fishes.

The scorpion-fishes [35] are so varied in form as to render a brief characterization of the group impossible. In the more extreme examples which are sure to attract attention great changes take place in the form of the fish and their appendages. The head may be distorted with ridges and grooves, the anal spines lost and the dorsal spines variously modified. The scales may be lost or replaced by warts or prickles, and in others the ventral fins may be reduced, while in still others the pectorals are often greatly enlarged.

They are especially abundant in the Pacific and form a large portion of the fish fauna of Hawaii, where ten genera and twenty or more species occur. In general, they do not migrate, but make a permanent home about the rocks and in the coral reef. Curiously enough, they are esteemed as food in spite of the fact that some of them have a venom sac at the base of the dorsal spine, to the poisonous effect of which they owe their name.

The noho or amakaha [36] is perhaps as typical and as common in the market and Aquarium as any of the scorpion-fish. They are indescribably mottled and streaked with brown, claret color, sulphur-red, salmon color and near-white. The inner or posterior side of the pectorals is brightly marked with yellow varied with black, so that when swimming from the observer they look like heavy-bodied butterflies winging their way about the tide pools in the reef.

The Sea-Bass Family.

Although it is customary for the angler to talk of the great variety of sea-bass to be caught in Hawaii, he doubtless speaks from the abundance of misinformation which is current on the subject of fish and fishing, and not from a desire to misrepresent the facts. Anything that takes the hook and in the

[34] *Echeneis* sp. [35] *Scorpænidæ*. [36] *Scorpænopsis gibbosa*.

least resembles a bass passes as one among this class of fishermen. As a matter of fact, there are but five species belonging to as many genera of the sea-bass [37] family that have so far been taken from Hawaiian waters. It is true that it requires some skill to detect the characteristics that separate the cardinal-fishes on the one hand and the catalufas and snappers on the other. If the fish in hand should prove to have three and only three stiff, strong spines in the anal fin and be bass or perch-like in form, the chances are it would prove to be a true bass. However, it would then require much consulting of authorities to prove the specific identity of the species, as the matter is further complicated by a disagreement in popular nomenclature as to whether it should be called a Jew-fish, a grouper, or a hind.

The hapu'u pu'u [38] is the most important and common species in the market, where specimens three feet or more in length are not uncommon. It is a dark purplish-brown fish with occasional irregular pearly spots on the sides and with black ventral fins, though in old specimens the spots disappear, leaving the fish a uniform reddish leather-brown. They are usually caught with a hook and are the only species of the bass family commonly known by a Hawaiian name.

One might naturally expect that the ocean about these islands would be inhabited by representatives of almost every type of animal to be found in the sea anywhere. However, the announcement of the discovery of the presence of the sea-devil [39] family close at hand will come in the nature of a surprise to many. That the creature was a new species and called for the creation of a new genus is made plain from its description, which, briefly put, characterizes it as an inky black animal with small eyes, a white mouth and a protruding chin. Any fear and uneasiness that may have been felt at the discovery of a member of this satanic family about the islands will be allayed somewhat when it is known that the only specimen of the genus ever discovered is less than four inches long and was dredged from the floor of the ocean under 500 fathoms of water.

SNAPPERS.

The snapper family [40] is represented in Hawaii by seven or eight important food fish. As has been stated, they closely resemble the sea-bass. One familiar with the characteristics of the two families, however, will be able to point out that in the snappers "the maxillary slips along its edge into a sheath formed by the broad end of the preorbital," while the sea-bass have no such sheath.

The eight species are all fairly abundant, carnivorous, voracious, gamey, excellent high-colored fish, and all are known at the marekt by Hawaiian names. The ukikiki [41] is a fairly common red fish with diagonal golden cross-bands. It is a fine, firm, white-fleshed fish especially suitable for baking. The

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[37] *Serranidæ.* [38] *Epinephelus quernus.* [39] *Ceratiidæ.* [40] *Lutianidæ.*
[41] *Roosevelti (Apsilus) brighami.*

PLATE 93. PARROT FISH, BUTTERFLY FISH, PUFFERS AND THEIR RELATIVES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. A Wrasse Fish (*Thalassoma umbrostigma*). 2. A Wrasse Fish [Hilu lauwili] (*Julis lepomis*). 3. A Parrot Fish [Uhu] (*Callyodon miniatus*). 4. Blue Parrot Fish (*Pseudosca-*

(Description of Plate Continued on the Opposite Page.)

opakapaka [42] is light rosy-olive with violet shades, especially on the scales over the back; the ulaula [44] is a beautiful rose-red or reddish-pink, while the uku [45] is uniform light gray, the upper parts tinged with blue which on the head becomes dark blue. Some of the species may be procured almost every day, there being more than a hundred thousand pounds sold annually in the Hawaiian markets.

Soles.

Of the true soles [46] but two species were secured by the scientists of the Albatross, and they were taken only from deep water. But of the nearly-related flatfishes, especially the flounders,[47] five genera with a half-dozen species have been recorded. By far the most plentiful flatfish is the pakii,[48] a curious sand-colored fish with numerous eye-like markings of light grayish-brown and bluish-gray and some with blackish edges. They are mostly small in size, but are excellent when fried. In the Aquarium this flatfish loves to lie almost concealed in the sand. Both eyes have been moved by nature far over on one side of its head. It is indeed a natural wonder that well repays the trouble it often takes to discover it when it has hidden itself in the sand and pebbles for protection.

Squirrel-Fishes.

The squirrel-fishes [49] are conspicuous shore fishes frequenting the rocky banks and coral reefs of the tropical seas. They are usually red or reddish in color and have eleven spines in the dorsal and four in the anal fin, the third usually being very strong. Five genera have been taken in the group, to which twenty gaily-colored species have been credited. Several of the species are abundant and are always to be seen in the market. The u'u [50] is the common red species that lives in the rocks. The natives have an interesting way of fishing for them. One is first caught on a hook, which they take quite readily. The fish is then attached to a line and dropped in again in some place suitable to the habits of the u'u. If the rock is inhabited the resident species will come out at once, bristling with rage, to drive off the intruder. Both fish are then lifted out with a hand net; the last one caught being substituted for the decoy—and so the fishing proceeds.

The alaihi [51] are interesting members of this family, represented by seven or more species that are quite abundant about the islands. They, like their

[42] *Apsilus microdon.* [44] *Etelis marshi.* [45] *Aprion virenscens.* [46] *Soleidæ.* [47] *Pleuronectidæ.*
[48] *Platophrys pantherinus.* [49] *Holocentridæ.* [50] *Myripristis murdjan.* [51] *Holocentrus* spp.

(Description of Plate Continued from Opposite Page.)

rus jordani). 5. A Butterfly Fish [Kikakapu] (*Chætodon unimaculatus*). 6. A Butterfly Fish [Kikakapu] (*Chætodon miliaris*). 7. Moorish Idol [Kihikihi] (*Zanculus canescens*). 8. A Surgeon Fish [Naenae] (*Hepatus olivaceus*). 9. A Surgeon Fish [Puala] (*Hepatus guntheri*). 10. A Trigger Fish [Humuhumu nukunuku apua'a] (*Balistapus rectangulus*). 11. Sharp-nosed Puffer [Puu olai] (*Canthigaster epilamprus*). 12. Porcupine Fish [Oopu kawa] (*Diodon nudifrons*).

cousins, are mostly small high-colored fish and are peculiar in the development of small spines almost everywhere over the surface of the body. The name refers to the noise they make when taken out of the water, which suggests the bark of the squirrel. The stripes on some species also add to their squirrel-like appearance.

The Surgeon-Fishes.

The surgeon-fishes or tangs[52] are herbivorous inhabitants of the tropical seas, notably abundant about the coral reefs and in the tide pools along the shore. They undergo great changes with age, the young often having been described as distinct genera. Hawaii has five genera and perhaps a dozen and a half species of these interesting fishes. They are mostly dark in color, with some vivid color added, and all have an armament developed on the side of the tail. In some genera this armament consists of a movable spine set with the point turned forward which can be dropped down into a sheath-like groove. In other genera one or two sharp knife-like plates are rigidly attached to the side of the tail. It is from these spines that the fishes derive their common names, surgeon-fish, doctor-fish, or lance-fish, and they form very effective weapons against their enemies, be they fish or man.

The pa kuikui[53] is common about Honolulu, and may be recognized by its brown color, which is relieved by an orange patch about the murderous spine on the side of the tail. The nae-nae[54] is olivaceous and has a bright spot on the shoulder. The pualu[55] is a common species in the Honolulu market. It is brown in color and has four or five golden longitudinal bands on the dorsal fin and four similar ones on the anal. The most abundant member of the extensive genus, however, is the delicious panfish known to everyone as manini.[56] They are almost daily offered for sale in the markets; their dull olive-gray bodies crossed by five narrow vertical lines renders their identity easy and certain. They are seldom more than seven or eight inches in length, but their small size is more than made up for by their delicate flavor when fried. They are fearless shore fishes, usually to be seen in pools in small schools. The young are often trapped in holes in the rocks along shore as the tide recedes, where they swim about without alarm, patiently awaiting the return to the sea. They are hardy and thrive in the Aquarium, where their stripes have won for them the popular name of convict-fish.

The kala,[57] or unicorn-fish, is an abundant member of the family. In addition to the two large pale blue, blunt, immovable spines on the tail, placed one in front of the other, it has as a special distinctive mark a long horn growing forward from the cranium above the eyes.

The Goat-Fish.

The surmullets, or goat-fish[58], are shore fishes of moderate size and possess the notable features of two long unbranched barbules of firm sub-

[52] *Acanthuridæ.* [53] *Hepatus achilles.* [54] *Hepatus olivaceus.* [55] *Hepatus guntheri.*
[56] *Hepatus sandvicensis.* [57] *Acanthurus unicornis.* [58] *Mullidæ.*

stance on the chin. These they employ for feelers, using them to stir up the sand on the bottom, as they search for the small animals upon which they feed. Their scales are large and thin, and the fish are all bright-colored, usually red or red and golden. About a dozen and a half of closely-related species are found in the ocean about Hawaii. These are divided among three important genera. Weke is the name applied by the Hawaiians to a number of the species. The name is also used in combination with more specific descriptive terms, so that weke or weke ula [59] is specifically applied to the bright red-colored surmullet of which enormous quantities are annually marketed in the islands. In the Aquarium they attract much attention as they swim along carrying their chin barbules extended in advance of them, cautiously feeling their way as they go.

The goat-fish proper [60] are represented by the moano,[61] the munu [62] and the kumu,[63] all of which are highly-colored common species.

Swordfish.

Occasionally a swordfish [64] is taken by the Hawaiian fishermen, and in this way reaches the market under the name a'u. They are fishes of great size, with the upper jaw prolonged to form a "sword," which is flattened horizontally. So far as is known, the family [65] is represented by a single species of world-wide distribution. They are mainly pelagic in their habits and are among the most predaceous and savage of the monsters of the deep. They not only transfix their ordinary prey with their formidable sword, but use it in a merciless attack on whales, which, from repeated stabs, often succumb.

Occasionally this pugnacious fish mistakes a ship's hull for an enemy and charges it, sending its sword crashing through several inches of timber. On one occasion the writer photographed a swordfish bill that had been rammed through the stern sheets of a small deep-sea-going craft. The vessel had been hauled out of the water for repairs in Honolulu harbor, when, to the surprise of the ship's master, the beaks of the swordfish were found driven deep into the hull, one of them piercing the solid pine shell to a depth of twelve inches. While swordfish are usually four to six feet in length, they may measure twelve or fifteen feet and have a sword a yard in length. The largest animals sometimes weigh as much as 600 pounds or more. The flesh of the swordfish is red in color and rich in flavor, and is everywhere prized as delicious food.

The trigger-fish [66] are rather large-size shore fishes that are partly herbivorous and partly carnivorous in habit. They are rarely used as food, and some of them are reputed by the natives to be poisonous. They are remarkable and interesting in that the first dorsal fin is composed of a short, stout rough spine with a smaller one behind it, and usually a third so placed that, by touching it, the first spine may be rigidly set or easily released, when it folds

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[59] *Mulloides auriflamma.* [60] *Pseudupeneus* spp. [61] *Pseudupeneus multifasciatus.*
[62] *Pseudupeneus bifasciatus.* [63] *Pseudupeneus porphyreus.* [64] *Xiphias gladius.* [65] *Xiphiidæ.*
[66] *Balistidæ.*

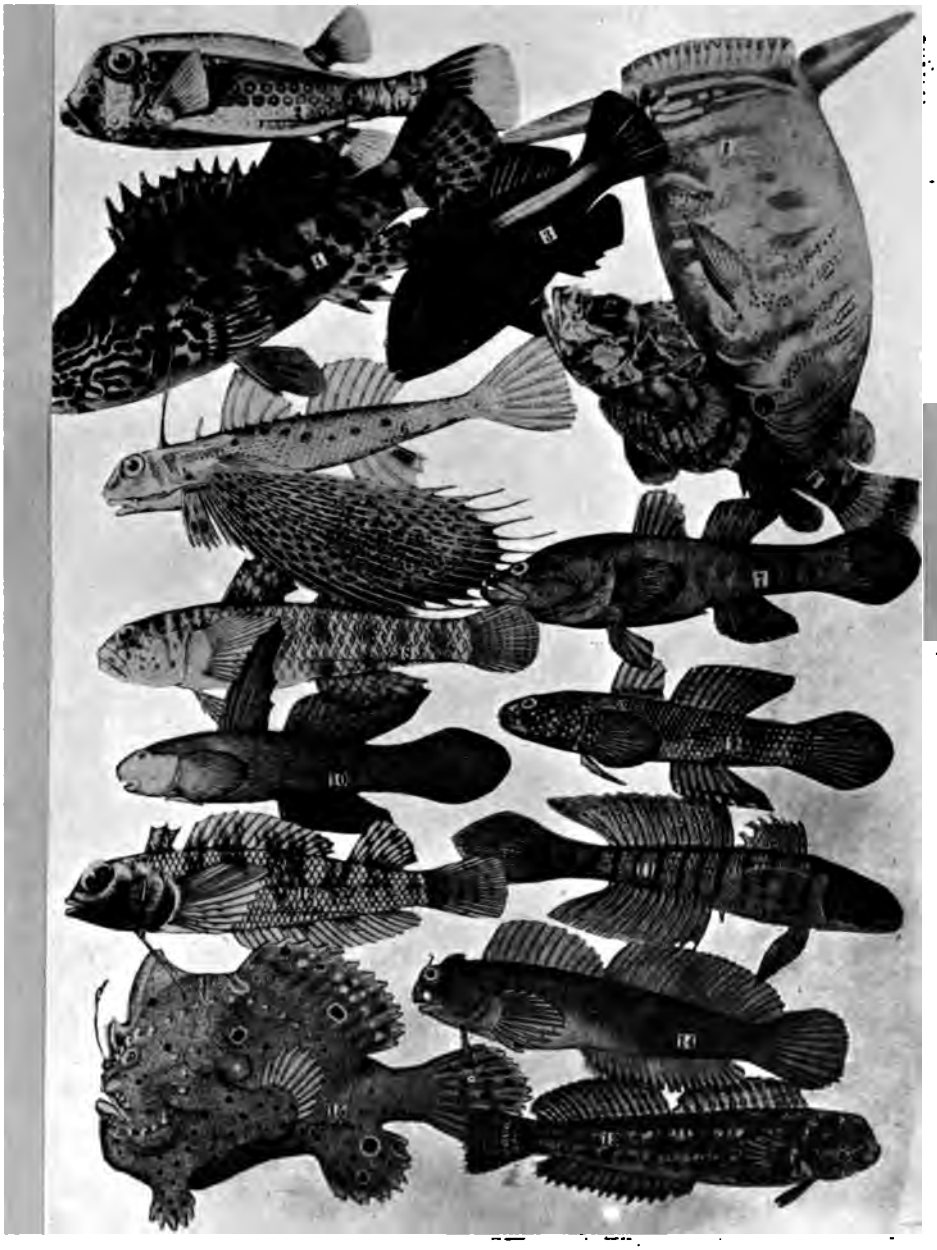

PLATE 94. GOBIES, BLENNIES, FROG FISH, TRUNK FISH AND OTHER ODD FORMS.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Headfish [Apahu] (*Ranzania makua*). 2. Trunk Fish [Moa] (*Ostracion sebæ*). 3. A Cirrhitoid Fish [Pilikoa] (*Paracirrhites forsteri*). 4. A Cirrhitoid Fish [Oopukai]

(Description of Plate Continued on the Opposite Page.)

The Trigger-Fishes.

back into a pocket out of the way. This gives the family the name of trigger-fish, as well as the older name, *Balistes*, which refers to a cross-bow shooter.

Hawaii has five genera with eleven species. The species of the principal genus *Balistes*, are known as humuhumu, to which as occasion requires is added a second name and even a third by the natives for more specific designation.

Many of the Hawaiian species are most fantastically colored. The humuhumu nukunuku a pua'a[67] has a blue band over the nose, a broad black one slanting diagonally across the body from over the forehead to the pectoral region, thence backward to the anal fin, and a wedge-shaped black band on the side of the tail; but several of its cousins outdo it in striking and unconventional colors and markings.

Trunk-Fish.

The odd, box-like trunk-fish,[68] or coffer-fish, as they are called by some, have the body enveloped in a boney box of six sides out of which the movable jaws, fins and tail protrude. They live in shallow water, are slow of motion, but often are brightly colored.

Five species of trunk-fish have so far been recorded from Hawaii. The moa[69] are conspicuous in their dress of bright blue with golden spots, and are the most abundant of the island species. Their knowing, stolid countenances as they swim gracefully about among their associates at the Aquarium give them a "position among fishes that corresponds to that held by the owls among birds." When taken from the water these fish will live a considerable time, and they appear to be hardy enough to commend them to keepers of private salt-water aquaria.

Trumpet-Fish.

The trumpet-fish,[70] known locally as the nunu, is not uncommon about the islands. By reason of its odd, elongated body, long head and small mouth set at the end of a long compressed tube, the nunu is sure to attract attention. The single species varies greatly in color, ranging from light yellow to dark brown, varied with five or six narrow longitudinal stripes. In spite of its odd appearance, it is a food fish of some importance, and is often exposed for sale in the markets.

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[67] *Balistapus rectangulus.* [68] *Ostraciidæ.* [69] *Ostracion sebæ.* [70] *Aulistomus valentini.*

(Description of Plate Continued from Opposite Page.)

(*Cirrhitus marmoratus*). 5. A Scorpion Fish [Nohu] (*Scorpænopsis gibbosa*). 6. Flying Gurnard [Lolo-oau] (*Cephalacanthus orientalis*). 7. A Goby [Oopu] (*Eleotris sandwicensis*). 8. A Goby [Oopu] (*Eviota epiphanes*). 9. A Goby [Oopu] (*Mapo fuscus*). 10. A Goby [Oopu] (*Sicydium stimpsoni*). 11. A Goby [Oopu] (*Awaous genivittatus*). 12. A Blennie (*Enneapterygius atriceps*). 13. A Blennie (*Alticus marmoratus*). 14. A Blennie (*Salaris zebra*). 15. Frog Fish (*Antennaris leprosus*).

CHAPTER XXIX.

INTRODUCED FRESH WATER FISH.

GOLDFISH.

Several attempts have been made by private citizens to introduce well-known food, game and ornamental fish into the Hawaiian Islands. One of the earliest, if not the first attempt of this nature, resulted in introducing the well-known goldfish [1] into the streams, ponds and irrigation ditches of Oahu, from whence they have been generally distributed to the other inhabited islands of the group. The original stock of goldfish came from China, but the date of the first shipment is not known. As early as 1867, however, they were being exported to California, and from that time to the present they have been abundant about Honolulu, and have contributed their share to the ideal beauty of the streams and the pleasure of the young angler. Since the original introduction some of the fancy varieties have been liberated at different times, with the result that there is much variation in form and color among the wild species. Goldfish are regularly offered for sale in the market in Honolulu, but they are mainly eaten by the Chinese and Japanese.

The goldfish is a native of China, and from there it was introduced into Japan at an early date. From Japan they were carried to Europe in 1611, and later to America, where many of the various artificial varieties that have been produced in China and Japan are reared with great success by fanciers. The rich golden color is found only in the domesticated species, and is retained by artificial selection. The native fish are olivaceous in color, and in the ponds and ditches about Honolulu, as in China and Japan, they readily revert to that color. In the Orient several score of forms have been produced by patient selection and breeding. Eighteen forms of so-called toy goldfish are known among the fanciers, each of them provided with a name based on its origin, history, form or color.

They are rather sluggish, hardy creatures that devour large quantities of mosquito larvæ from pools and fountains about the city. Unfortunately, the more recently introduced "mosquito fish" are reported to feed on the eggs and very young of the goldfish and mullet, as well as the mosquito larvæ and the young of the fresh-water shrimp. As a result, goldfish are not as plentiful in our streams as they were formerly.

CARP.

Carp [2] were introduced into the islands from America some years ago. They were first planted in the irrigation ditches near Wailuku, and from there were distributed to Hawaii and Oahu, and doubtless will be found on all the islands. They are not much used as food on account of their muddy flavor and are only used in the absence of better fish. They naturally

[1] *Carassius auratus.* [2] *Cyprinus carpio.*

prefer shady, sluggish water with muddy bottoms, where they feed voraciously on small water animals and vegetable matter, particularly the leaves of aquatic plants. The common carp is closely related to the goldfish and was originally a native of the rivers of China, where it has long been artificially reared by the inhabitants. From there it was introduced into Europe, perhaps three centuries ago, and has since become naturalized and several varieties produced in domestication. From Europe carp were introduced into America, and from America they were brought to Hawaii, thus completing their journey around the globe. They attain a size of several pounds and may be identified as the only scaled fresh-water fish in Hawaii that have barbules on the upper lip. A single specimen has been known to produce as many as seven hundred thousand eggs in a single season.

Catfish.

The common bullhead catfish, or horned pout,[3] was introduced about twenty years ago from California, where it had been naturalized, and was planted in ponds about Hilo, but it has not been seen since. In the meantime it has been introduced on the Island of Oahu, where it has been secured from the same ponds with the Chinese species. The Chinese catfish[4] was introduced by the Chinese about a dozen years ago from their country. It has survived and is becoming quite common in the fresh-water ponds and finds its way to the markets, where it is sold under the name of Chinese catfish.

Since both species occur about Honolulu in the same environment, it will be well to know that the Chinese species have the dorsal and anal fins much elongated, each with many rays, and extending throughout the greater length of the trunk, while in the bullhead the dorsal and anal are much shorter, the dorsal with one hard and seven soft rays.

China Fish.

Easily mistaken for the Chinese catfish in the water, is the "China fish,"[5] which in reality is a snake-head mullet. They are long and cylindrical, and the head is covered with scales. They are carnivorous and voracious in habit, and are extremely tenacious of life, living for hours out of water when thrown on the banks of the irrigation ditches or when carried to market. Dr. A. Günther states that they are able to survive drouth by living in the semi-fluid mud or lying in a semi-torpid state below the hard sun-baked crust of the bottom of a tank from which every drop of water has disappeared.

Black Bass.

The first attempt to establish black bass dates from the summer of 1897, when a shipment was made from the California Fish Commission to a number of citizens at Hilo. Unfortunately, only twenty-one of these elegant sun fishes survived the journey. These were planted in Wailuku river near Rainbow

[3] *Ameriurus nebulosus.* [4] *Clarias fuscus.* [5] *Ophicephalus striatus.*

Falls, but the following day a heavy freshet in the river is supposed to have carried them out to sea, as they were never seen afterward.

In 1908 Mr. W. A. Templeton, while visiting California, secured a number of large-mouthed black bass[6] which he brought back with him and planted in the great artificial fresh-water reservoir at Wahiawa. Under his supervision the introduction has proved successful, and this exceedingly valuable game fish is now well established in these waters and in time will doubtless be carried from Wahiawa to similar reservoirs and ponds throughout the group. As these ponds are filled with shrimp and the temperature and other conditions seem favorable, the black bass is doubtless to become a common article of food in Hawaii and will prove a worthy substitute for almost any of the native fish.

Trout and Salmon.

Attempts to establish trout in Hawaii have so far proved unsuccessful, though two or three attempts have been made, the first as early as 1876. It is thought by the writer that there are streams in the group, especially one or two on the Island of Molokai, that are well adapted to the trout, and that if proper precautions were observed in planting them, they would soon establish themselves. Salmon eggs were sent here for planting in 1876, but this experiment proved unsuccessful.

Mosquito Fish.

Work along the line of mosquito control had advanced in the Territory to a point where, on the advice of experts, it was deemed advisable to import small fish for the purpose of feeding on the larvæ of this pest that hatches in the streams, ponds and ditches of the Territory. The Legislature of 1905 made a small appropriation for that purpose, and a special collector was employed to transport to Hawaii representatives of the so-called "top minnows" or killifish from Galveston, Texas. Three species[7] belonging to three genera of the family *Poeciliidæ* were successfully introduced into especially-prepared ponds at Moanalua, Oahu. From these they have since been spread broadcast over the group until it is now almost impossible to find slowly-moving or standing fresh water that is not inhabited by one if not all of the species. They are silvery fishes of small size, scarcely more than two inches in length. They have a wonderful appetite, devouring large quantities of mosquito larvæ, but, as was expected, they do not discriminate as closely as might be desired, with the result that they are charged with eating the eggs and young of the other aquatic animals. However, the introduction of a few into any closed body of water infested with mosquito larvæ will convince anyone of their economic value to the Territory. Their small protractile mouths, scaled heads and "minnow" shape is sufficient to separate them from other fresh-water fish, but the species are so small that their certain identification by the novice is not an easy matter.

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[6] *Micropterus salmoides.* [7] *Gambusia affines, Fundulus grandis* and *Molienesia lattipinna.*

CHAPTER XXX.

IMPORTANT ECONOMIC INSECTS: PART ONE.

The insect life of Hawaii is as yet far from being completely explored. However, through the patient researches of a number of specialists extending over a period of years, the native and introduced fauna is becoming better known, though all testify to the many insect rareties as well as pests yet to be found by almost any one who will search with patience and industry in the rich fields offered by the wonderful variety of environments to be met with in the islands.

Importance of the Study of Insects.

The study of the habits of insects by young people as a part of their school work, or on their holiday excursions, is especially to be commended, since it is sure to result in the learning of many valuable lessons that deal with the wonders of nature. Besides being of absorbing interest to old and young, such study may lead the enthusiast to follow a pursuit in life that offers possibilities of great usefulness and benefit to all.

The tourist and visitor, however, whose conception of the islands has been too literally based on some traveler's account wherein the tropical forests are portrayed as "a wilderness jeweled with a myriad brilliant-colored butterflies," is sure to be disappointed on his first expedition into the mountains of Hawaii. While they are plentifully stocked with insect life, unfortunately from some points of view it is not of the gorgeous and showy kind that one is wont to associate with tropical islands.

The few small dull-colored species the novice is able to collect on the first day's outing are usually not such as to excite much enthusiasm for Hawaii as an insect collector's paradise. But on careful study of the day's catch it will be found that many of the insects belong to species that cannot be found elsewhere in the world, and that many of them have habits of the most absorbing interest. Further and more searching study of the fauna will bring to light peculiar local representatives of almost all of the great orders of insects. When we consider the isolation of the islands, one is surprised to find represented so great a proportion of the large number of families into which the world's more than three hundred thousand known species of insects have been classified.

Important Destructive Species.

As there are several thousand species that are native to the islands, a few of which are touched upon in a succeeding chapter, and since there are several hundred that have been introduced by accident or design,[1] only the briefest notice can be taken in this chapter of a few of the more important economic species that, for one reason or another, are liable to attract the attention of

[1] As many as one hundred and thirty-six species being intercepted and prevented from landing at the wharf during the biennial period ending December 31st, 1914.

PLATE 95. THE STUDY OF ECONOMIC INSECTS.

1. Interior of an insectory showing breeding cages. 2. Sugar cane showing the work of the Sugar Cane Borer (*Rhabdocnemis* = (*Sphenophorus*) *obscurus*). 3. Office and cabinets of the Territorial economic entomologist.

the ordinary observer, or those persons whose occupations often bring them in touch with things of nature.

It is a singular fact that of the large number of species peculiar to the islands only a few are noticeably destructive to agriculture or to cultivated exotic plants. The worst enemies of the agriculturist have been introduced from abroad and are frequently cosmopolitan pests. They usually come with farm produce, ornamental plants, earth and seeds. The result is that one is liable to meet here in the islands all of the old enemies of the husbandman with which one may be familiar in his native country, and to the list may be added several other forms equally destructive that were before unknown to the observer.

The number of destructive insects in the islands has led to the adoption of the policy of controlling them whenever possible by the introduction of their natural enemies. This plan has been steadily pursued for almost a quarter of a century, with the result that probably in no other country, particularly when its size is considered, have so many beneficial insects been artificially established.

Control by Natural Enemies.

As the natural enemies of most of the insects are parasites, which as very minute insects, usually attack and feed in one way or another upon the host species which itself is often microscopic in size, this warfare is not a very conspicuous one, nor one liable to attract very much attention. However, in the struggle being continually waged to keep the enemies of agriculture in check in the islands, these often unseen and unknown insect friends are always active and have already saved millions of dollars to Hawaii.

The Sugar-Cane Leaf-Hopper.

Perhaps no more remarkable example of the effectiveness of this method of control can be found than that of the introduction of the leaf-hopper egg parasites. The cane leaf-hopper had been known to plantation managers and expert entomologists in the islands for a number of years, but in the early spring of 1903 it appeared so generally throughout the cane fields and in such numbers as to prevent the growth of the cane. It was found to be a typical member of the leaf-hopper family (*Asiracidæ*), and proved to be a recent introduction, probably brought with seed cane from Queensland, Australia. Owing to its small size and inconspicuous color and habits, its spread was unnoticed until it could be found almost wherever cane was grown.

The sugar-cane leaf-hopper[2] flies readily and is attracted long distances by light; so besides traveling with the cane, it flew to new fields and from one plantation to another.

A peculiar smut that developed on the lower leaves of cane attacked by the leaf-hopper was found to grow on the "honey dew," a transparent sticky

[2] *Perkinsiella saccharicida.*

fluid exuded by the insect, and was one of the conspicuous signs of the subtle attacks of the troublesome bug.

As the development of the insect from the egg to the adult is not divided into definite stages, as is the case with the butterfly for example, the young when hatched resemble the adult, except they do not at first have wings. The wings are acquired, however, by a process of moulting, and in due time the insect is fully matured. The eggs, necessarily quite small are deposited along the mid-rib of the leaf, or in exposed portions of the stalk. The place of insertion is marked at first by a white spot with a waxy covering over the opening. Four to six eggs are deposited in each opening; moreover, several clusters are deposited by a single female.

As time passes the white spot, if occupied by living eggs, becomes claret-colored. When first hatched the young are almost colorless. After some effort they emerge from the nest and begin to feed. They continue to feed until they develop their wings, and finally die of old age. As a rule they do not fly when disturbed, but sidle to the opposite side of the leaf or jump to a more secluded spot.

Scientific study of their habits shows that the first injury done to the cane by them is when it is punctured for the deposition of the eggs. The puncture produces a drain on the plant's vitality and admits various diseases through the wound. But the most serious injury is that done by the young insects to growing cane.

Everything that ingenuity could devise was tried to lessen the damage done by them, but without success. The seriousness of the invasion was soon appreciated and scientific entomologists were speedily assembled in Hawaii, and from here sent out to all promising countries to look for the most effective natural enemies of this insect pest, a pest that had already cost hundreds of thousands of dollars in diminished returns from this important crop. When the entomologists went seriously to work they found a number of natural enemies of the hopper. But in choosing the most desirable and efficient one, they had to consider their effectiveness, the possibility of their transportation, the probability of their thriving, and the rate of increase to be expected when they were once established.

It was found for the work to be done that certain little egg parasites were very promising, since they completed their life cycle every three weeks the year round, and the greater part of those produced were females. With such habits it was plain that within a very few months after the original colonies were liberated, thousands of millions of descendants of the original stock would be at work searching out the spots on the cane where the leaf-hoppers had deposited eggs, and in turn depositing their own eggs in them in such a way that the young of the parasite would feed upon and kill the eggs of the leaf-hopper before they had time to develop.

When the proper data had been secured, the egg parasites were imported into Hawaii, the species carefully studied in captivity, and the young parasites

liberated on all the important plantations. Science was thus again called to the aid of the planters, as it had been many times before, and the experiment worked out has been so successful that the effects of the leaf-hopper on the cane crop of Hawaii is almost a negligible quantity. The outbreak is now under control, and the whole industry saved and restored to its normal condition.

The Sugar-Cane Borer.

The search for the parasites feeding on the almost equally destructive sugar-cane borer[3] has been a thrilling scientific adventure. Happily, after years of search, Dr. Frederick Muir was rewarded by the discovery, and subsequently succeeded in the successful introduction into Hawaii, of parasites to prey upon this most destructive insect.

Lantana Insects.

Examples of the controlling of injurious insects by introducing their insect enemies might be multiplied at length, but one more instance, of a somewhat different nature, in which insects were used to combat the spread of an injurious plant must suffice. A great many years ago (1858) the common Lantana,[4] a native plant of the subtropical regions of South America, but elsewhere cultivated extensively as a green-house or ornamental shrub, was introduced into Hawaii as a garden plant. In course of time the mynah bird, which was likewise introduced, made the discovery that the small blue-black aromatic berries of the Lantana were edible. As a result, in a very few years this hardy plant had been spread broadcast to all parts of the group by these birds. Thousands of acres of what was formerly open pasture land became completely choked with the rank growth, while even in the lower forests it grew several feet in height, often forming an almost impenetrable, though beautiful, flowering jungle.

Although the plant was regarded as beneficial by reason of its power to force its long roots down deep into the earth, thereby loosening the soil and furnishing to it a large amount of humus as fertilizer, its inroads into pasture and tillable land became so marked and persistent as to cause it to be regarded as a serious scourge. Entomologists began to look into the natural enemies of the plant, and before long had found a number of insects and fungus parasites that naturally fed on the Lantana, preferring it to any other food.

By far the most important among these is the Lantana seed-fly,[5] which is a small black two-wing insect, the maggot of which lives in and destroys the seed. So perfectly has it done its work that in favorable localities it is difficult to find a seed that has not been killed by this insect. This is of great importance, for if land is once cleared of Lantana it will not grow again, though unfortunately guava often springs up to take its place.

The Lantana plume-moth,[6] a small brown moth about a half inch in

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[3] *Rhabdocnemis = (Sphenophorus) obscurus.* [4] *Lantana Camara.* [5] *Agromyza* sp.
[6] *Platyptilia* sp.

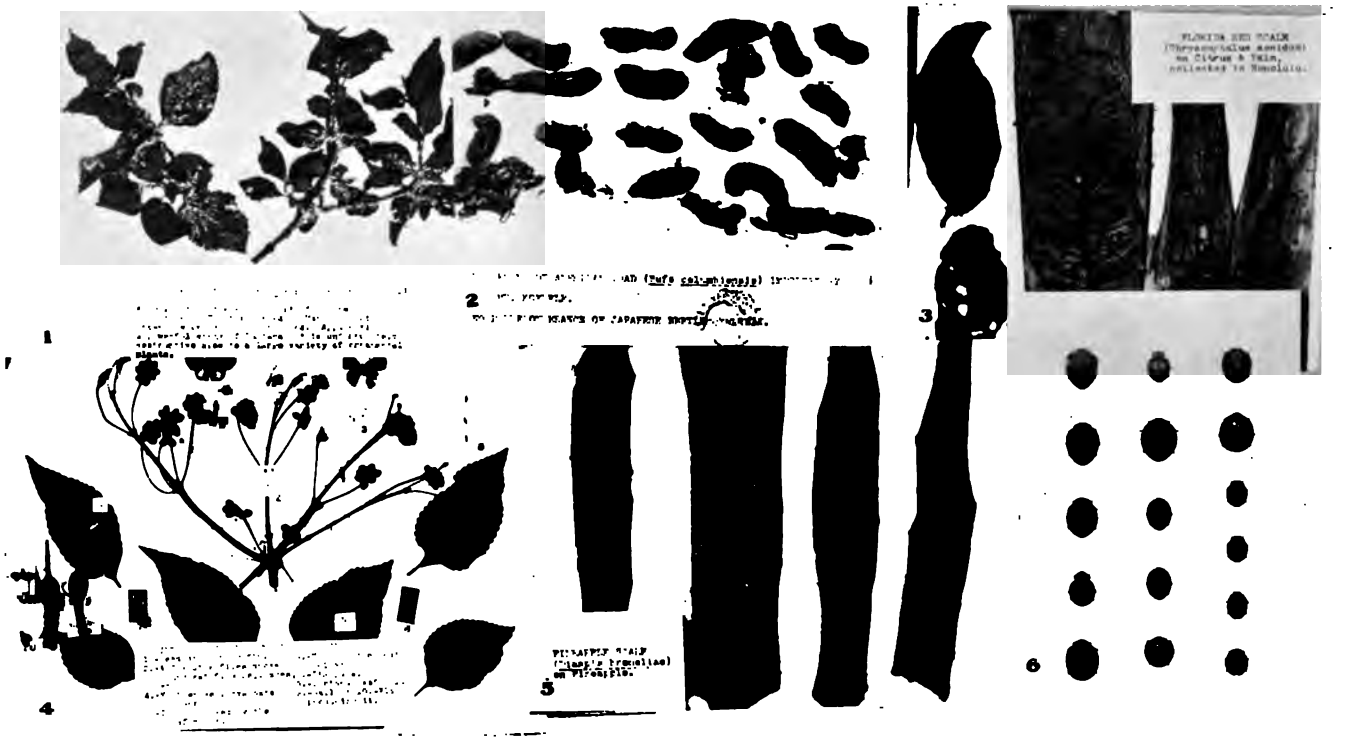

PLATE 96. SOME ECONOMIC INSECTS.

(For Description of Plate See Opposite Page.)

expanse, is also an important species in destroying Lantana, as it lays its eggs at the base of the flower cluster. On hatching, the minute caterpillar digs a tunnel under the flowers and attacks and destroys them. The work of this species on the flowers is supplemented by the work of two species of Lantana butterflies[7] of the family[8] of gossamer-winged butterflies, both of which lay their eggs on the flowers so that the young worms may feed on the blossoms and fleshy seed. These caterpillars are so abundant among the Lantana of the low lands that they occur in almost every flower. The larger species[9] has delicate tails on the hind wings; the smaller species[10] is without the tails.

The Lantana leaf-miner[11] is a moth that is also effective, since it develops in the leaves up to the pupa or resting stage. Often as many as a half dozen of these miners occur in a single leaf and thus produce a serious drain on the plant's vitality. A second leaf pest is the Lantana leaf-bug,[12] which, being a true bug, sucks its food. The young frequent the under side of the leaf and are very destructive during the dry season. The Lantana gall-fly[13] also does much damage to the pest host by laying its eggs in the stem of the plant. These form galls that further impair the plant's growth.

All of these insects were introduced for a definite purpose under the direction of the distinguished entomologist Mr. A. Koebele, and none of them have been observed to attack other plants. This is the first example in the world of the introduction of insects to prevent the spread of a plant. As time passes, the success of this delicate and difficult piece of scientific work is more and more fully appreciated by scientists as well as citizens. It furnishes science with another convincing example of the value of the study of entomology, and indicates the power of the subtle influences in nature with which the biologist is wont to deal.

The Maui Blight.

In speaking of Lantana insects, it is only just to say that the Lantana blight or Lantana scale[14] or Maui blight, which is the great tea pest of southern Asia, was not introduced by Mr. Koebele. It was first found at Wailuku, on Maui, in 1889. In 1904 it was noted on Lantana on the windward side of the Pali, on Oahu. Since then it has spread even into Honolulu,

[7] *Thecla* spp. [8] *Lycænidæ*. [9] *Thecla echion*. [10] *Thecla agra*.
[11] *Cremastobombycia lantanella* Busck. [12] *Theleonemia lantanæ*. [13] *Eutreta sparsa*.
[14] *Orthezia insignis*.

Description of Plate.

1. Maui Blight or Lantana Scale (*Orthezia insignis*) on Lantana. "A well known greenhouse pest of Europe and America. First observed on Maui, though not known by whom or how introduced. Apparently a powerful enemy of Lantana, but unfortunately is destructive also to a large variety of ornamental plants." 2. Excrement of American Toad (*Bufo columbiensis*). The Toad feeds very largely on the Japanese beetle. 3. Florida Red Scale (*Chrysomphalus ficus*) on Citrus and Palm leaves. 4. Imported enemies of the Lantana showing: (a) seed destroyed by fly; (b) and (c) butterflies whose young eat flowers and leaves; (d) moth whose young eats the flowers; (e) injury caused by the leaf-miner; (f) moth of the leaf-miner; (g) its pupa; (h) the Lantana leaf-bug; (i) the gall and (j) the fly producing it. 5. Pineapple scale (*Diaspis bromeliæ*) on pineapple leaves. 6. Australian Ladybird beetles introduced into Hawaii.

where it occurs as a pest on a number of ornamental plants, most noticeably on the species of Gardenia and Coleus.

The scale has a white body and black head, and its presence induces the growth of a sooty mould so that everything it overruns turns black, often leaving whole fields of Lantana leaves in a blackened condition as though run through by fire. It is a decidedly beneficial parasite working against Lantana, and were it not for its unfortunate tendency to spread to beneficial and ornamental plants, it would have been credited with a large share of the laurels due the insects that have given man the control over this plant pest.

The effect of the Maui blight on Lantana-ridden pasture land was early recognized by ranchmen, and it is said by some that they very unwisely aided in its spread to new fields and to different islands. Fortunately, as yet it has done more good than harm, though there are many who are fearful of what it may do in the future.

Of the effort of man to secure control over the Lantana in Hawaii, it can be said that the work done by scientific men in seeking out, introducing, breeding and spreading the natural enemies of this noxious plant has been singularly successful; so successful, indeed, that everywhere in the group the pest has been arrested in its invasion of the land, while in certain localities Lantana has been completely routed by its minute enemies. Brilliant and successful as has been the Lantana campaign, there is unfortunately a long list of introduced insect pests[15] for which, in spite of the fact that persistent search has been made to secure them, there seems to be no known effective natural parasitic or predaceous enemy.

The Mediterranean Fruit-Fly.

As one of the most recent as well as the most troublesome introductions in this class, the Mediterranean fruit-fly[16] may well be mentioned, as there is scarcely a fruit grown in Hawaii that is not attacked by this pest. It is about the size of a common house-fly; the body is yellowish, the eyes of a reddish-purple tint, and the back and wings variously marked with blotches and lines of black, yellow and dirty white. The home of the species is supposed to be about the Mediterranean, perhaps in Africa, from whence it has been distributed by commerce to many lands, among them Australia. From Australia the fly has doubtless been introduced into Hawaii.

The eggs are inserted by the female fly in the various kinds of fruit when they are just turning ripe. By the time the fruit is ripe the white wriggling maggot is ready to emerge. Leaving the fruit, it burrows in the ground a short distance and forms for itself a wheat-shaped pupa case from which it emerges in a few days as an adult.

The species was first noticed in Honolulu during the summer of 1910. By the summer of 1912 it had spread to all the large islands of the group and is now common wherever fruit is grown.

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[15] Among them many that are exceedingly troublesome. [16] *Ceratitis capitata.*

Melon-Fly.

A somewhat larger and handsomer, though similar appearing fly pest, is the melon-fly.[17] It was first noticed on Oahu as long ago as 1897, and since that time has succeeded in doing for the melons and fleshy vegetables what the fruit-fly has done for the fruit of the islands. They not only infest the fruit, but the vines as well, and as there is an abundant variety of plants on which they feed, they ravage the truck gardens throughout the year.

The Horn-Fly and Other Injurious Flies.

The horn fly[18] is a pest of the live stock of the islands; the damage it does is of equal rank with the fruit and melon-flies. It was introduced from California in 1897, and within a year had spread throughout the group. In the years that have passed it has bred uninterruptedly, and the annoyance caused by its blood-sucking habits has been felt by all the live stock on the Hawaiian ranches. Owing to its vicious bite, a loss of hundreds of thousands of dollars has been sustained by ranchmen through the shrinkage in weight of animals to be sent to market.

Other flies that have more or less economic importance are the stable fly;[19] the horse bot-fly,[20] found on horses or about stables; the sheep-head maggot fly;[21] two flesh flies;[22] two bluebottle flies;[23] the sheep-maggot fly[24] on sheep; and warble-flies of two species[25] on cattle. The familiar house fly[26] is everywhere present and in some localities abundant, though it is kept in control by parasites[27] that make it their host, and to some extent doubtless by certain species of ants.

Mosquitoes.

With the flies as members of the great order *Diptera,* should be considered the representatives of the mosquito family. Of these, three important mosquitoes, the night mosquito[28] and the two day mosquitoes, one[29] with two white stripes on each side of the thorax, and the other[30] with one white stripe on the thorax, are common in the islands. They are so abundant in certain localites as to be the principal source of man's discomfort in Hawaii. So far they have not themselves become innoculated with the diseases which elsewhere they transmit from one person to another, producing, in the case of one of the day mosquitoes,[31] the dreaded yellow fever of tropical and subtropical countries. Through the introduction of natural enemies, as the mosquito fish, frogs, dragon flies and the like, in connection with the various campaigns to do away with standing water, which is their natural breeding place, all of the species have been materially reduced in numbers in Honolulu, but they are

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[17] *Dacus cucurbitæ.* [18] *Hæmatobia serrata.* [19] *Stomoxys calcitrans.* [20] *Gastrophilus equi.*
[21] *Œstrus ovis.* [22] *Sarcophaga barbata* and *S. pallinervis,* the latter with a red tip to the abdomen.
[23] The European bluebottle, *Lucilia sericata,* and the American species, *L. cæsar.* [24] *Oestrus ovis.*
[25] *Hypoderma bovis* and *H. lineata.* [26] *Musca domestica.*
[27] *Eucoila impatiens,* the stable fly parasite, and *Spalangia hirta.* [28] *Culex fatigans.*
[29] *Stegomyia fasciata* (Fabr) = *S. calopus* (Meigen). [30] *Stegomyia scutellaris* (Walk.).
[31] *S. scutellaris.*

far from being under the complete control that it was hoped would be possible.

It is asserted on the best authority that mosquitoes were unknown in Hawaii previous to the year 1826, when the night flying species was brought from San Blas, Mexico, to the port of Lahaina, on Maui, by the ship "Wellington." Prior to the above date the Hawaiians had no word for mosquito. They almost immediately adopted the corruption "makika" as the native name of the insect. The day mosquitoes have been introduced during the present generation, but there is no definite record of the exact date.

Sugar-Cane Insects.

While mention has been made of the sugar-cane borer and the sugar-cane leaf-hopper as the most important pests of sugar-cane, it is not to be assumed that there are no others. As a matter of fact, there are more than sixteen insects liable to do more or less damage to the growing crop. Among them are four beetles.[32] The cane borer, a species which is known elsewhere, and is either an importation of man or a natural immigrant, as it is also found in the banana, pandanus, cocoanut palm and under stones in the mountains, is the most important of this order. The long-horned beetle[33] attacks the cane only accidentally, as its natural food is the decaying wood of forest trees, while a small borer,[34] and a nitidulid beetle,[35] which breeds in the parts injured by the mealy-bugs and plant lice, complete the list of beetles. There are three caterpillars,[36] including the sugar-cane leaf-roller.[37] Besides the leaf-rollers, the well-known troublesome peelua,[38] or grass army-worm, occurs occasionally in the cane. It is very troublesome in grass land at all seasons, occurring in millions of individuals at irregular intervals, working great havoc in pasture lands The four-banded fly of the family *Ortalidæ*[39] is sometimes found about injured cane. The grasshopper family[40] has four representatives, the African mole-cricket[41] being the most troublesome. They are blackish-brown insects an inch or more in length, that are peculiarly fitted for living in the ground. The front legs are modified to serve as very powerful spades and are used in much the same way that the common mole uses its fore paws. The mole cricket feeds on the tender roots of various plants, and where they are abundant become very destructive. Two species of grasshoppers, one the short-horned grasshopper[42] which was introduced about 1878, the other the long-horned species,[43] the latter species appearing first in Pauoa Valley about 1898, but now present in the cane fields, as well as elsewhere, feed to some extent on the succulent growth. The black beetle-roach, cypress roach[44] or ground cockroach, does some slight damage also.

As a matter of fact, two species of leaf-hopper that occurred in the islands prior to 1892 are found in the cane fields. They are known to have

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[32] *Coleoptera.* [33] *Egosoma reflectum.* [34] *Haptoncus* sp. [35] *Hypothenemus* sp. [36] *Lepidoptera.*
[37] *Omiodes accepta*, and probably allied species. [38] *Spodoptera mauritia.* [39] Perhaps *Euxesta annone.*
[40] *Orthoptera.* [41] *Gryllotalpa africana.* [42] *Oxya velox.*
[43] *Xiphidium fuscum* = *Xiphidium varipenne.* [44] *Eleutheroda dytiscoides.*

been imported, however, as they bear no resemblance to the great order of true bugs [45] that occur in the forests. The one previously mentioned, in which the wings do not touch each other down the back, and the corn leaf-hopper,[46] having the wings folded closely together on the back, are the important forms. A gray sugar-cane mealy-bug,[47] a pink sugar-cane mealy-bug,[48] and a plant-louse known as the sugar-cane aphis [49] are also members of the same great order.[50] They are injurious locally, and though their relatives are more or less readily kept in check on other vegetation, the latter species, when it occurs on cane, hides at the base of the leaves and is almost inaccessible.

It will be seen that some of these pests bore into the stem of the cane, some eat or cut the underground roots or stems, some eat the leaves, some suck the juice from the leaves and stems, and some feed on the parts left after other species have had their fill. Yet in spite of the formidable list of enemies and the diverse lines of attack which they pursue, some of the best and most favorably located plantations are able to harvest as much as thirteen tons of raw sugar of the finest quality from an acre of this seemingly pest-ridden plant.

Aphids or Plant-Lice.

The sugar-cane aphis,[51] since it probably occurs throughout the islands where cane is grown, may well be taken as the type of its family.[52] The aphids are minute insects with more than twenty species already known in the islands, all of which have been introduced.

Most of the species of plant-lice or aphids in Hawaii occur on well-known or imported plants, and were doubtless imported with their host plants. They are inconspicuous but are very injurious on account of their numbers and their juice-sucking habits. They make up in numbers for what they lack in size, and must be recognized as among the greatest pests with which the farmer, gardener and horticulturist has to contend.

The plant-lice and aphids are minute, soft, pulpy little creatures with rather long antennæ and conspicuous round eyes; they are commonly seen crowded together on the ends of stems, the under side of leaves, in buds and flowers, in clefts in the bark and sometimes even on the roots of plants. Their fore wings are longer than the hind pair and repose roof-like over the hind part of the body. While the majority of them are green in color, they vary greatly, being brown, black, red, yellow, and variegated. They are usually named after the plant on which they occur most abundantly. As a rule, though not always, they confine their attacks to a single species of plant. Among the more noticeable species in Hawaii we find the banana aphis,[53] the fern aphis,[54] the palm aphis,[55] the rose aphis,[56] the corn aphis,[57] the violet aphis,[58] the orange aphis [59] on citrus fruit generally, the chrysanthemum aphis,[60] the

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[45] *Hemiptera.* [46] *Peregrinus maidis.* [47] *Pseudococcus saccharifolii.* [48] *Pseudococcus sacchari.*
[49] *Aphis sacchari.* [50] *Hemiptera.* [51] *Aphis sacchari.* [52] *Aphidæ.* [53] *Pentalonia nigronervosa.*
[54] *Idiopterus nephrolepidis.* [55] *Cerataphis lantaniæ.* [56] *Macrosiphum rosæ.* [57] *Aphis maidis.*
[58] *Rhopalosiphum violæ.* [59] *Myzus citricidus.* [60] *Macrosiphum sanborni.*

coffee aphis,[61] the bamboo aphis,[62] and the cotton aphis,[63] occurring on cotton, Hibiscus, cucumber, taro, Portulaca and several other common plants.

The life history of the plant-lice is very interesting, but is exceedingly complicated. Although it differs somewhat in different species, it is always characterized by what is known as an alteration of generations. Thus several broods or generations of a species will appear during the year. Usually the young spring from eggs laid by a female capable of producing fertile eggs without the intervention of males. The females of some species give birth to living young instead of laying eggs. The true males are generally though not always provided with wings, but the true sexual female always has wings which enable her to carry her eggs to a distance and establish a new colony. Several wingless broods will follow one another parthenogenetically, when in course of time true sex individuals will appear[64] and mate, and the females go elsewhere to establish new colonies. A little study and calculation will show that millions of individuals may result from a single fertilized female in the course of a very few months.

The aphids, as well as many other insects, especially the leaf-hoppers, have the power of secreting a viscous saccharine substance called honey-dew. This they deposit on the surface of the leaves and stems of plants. It thus happens that the sugar-cane aphis and the sugar-cane leaf-hopper have been directly responsible for the increase in the production of honey in Hawaii, as the bees are very fond of this sweetish deposit and gather thousands and thousands of pounds of it annually. In fact, the bees gather so much of this substance that it has been necessary to give to this class of honey from these islands the distinctive name of "Hawaiian honey-dew honey," since honey-dew enters so largely into the composition of the local product. However, algaroba flowers furnish an immense amount of fine-flavored honey that finds a ready market here and elsewhere.

CHAPTER XXXI.

IMPORTANT ECONOMIC INSECTS: PART TWO.

Scale Insects.

The family of scale insects[1] includes the mealy-bugs and scale-bugs, or bark-lice. Like the aphids, they were practically all introduced into Hawaii with some of the host plants on which they are found. They owe their name to the fact that the females of many species look like oval or rounded scales attached to the bark, stems or roots of plants. The sexes are very dissimilar. The adult males, though very rarely seen, are provided with one pair of functional wings, the hind pair being rudimentary. They have rather long an-

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[61] *Toxoptera aurantiæ.* [62] *Aphis bambusæ.* [63] *Aphis gossypii.* [64] Usually in the autumn.
[1] *Coccidæ.*

tennæ and distinct eyes. The females are always wingless and generally, though not always, remain fixed at some one spot. In many species the female soon dies, leaving her body as a protection over the eggs until the young have hatched and begin to rove about in search of food, which they secure by puncturing the plant and sucking up the sap.

Scale insects are more numerous within the tropics than in the more temperate regions. They multiply rapidly and are very injurious to plant life. They infest a large number of fruit and ornamental trees in the islands, and are already firmly established, with representatives of most if not all the more injurious species found on the mainland, as well as from Australia and the Orient. In spite of the precautions taken to prevent their importation, along with other injurious insects, new species occasionally gain an entrance, and it is to be expected that they will continue to arrive in the future.

Like the aphids, their common name is generally derived from the plant infested by them, or at least the one on which they were first discovered or on which they are most prevalent; but it may also refer to the color or shape or some peculiarity of the insect. In addition to the sugar-cane mealy-bug already noted, we have the avocado mealy-bug,[2] occurring on avocado, fig grape, guava, mulberry, soursop, asparagus, etc.; the ivy scale,[3] the oleander white-scale,[4] occurring on oleander, mango, banana and avocado; the avocado scale[5] and pineapple scale,[6] occurring also on the Canna, Hibiscus, and a list of such plants. The last species may be readily distinguished from the Pine-apple mealy-bug,[7] which is a larger insect with a soft body that is white all over and is provided with well-developed legs. The cottony guava-scale[8] is found on coffee, citrus fruit, etc.; the black scale[9] on sisal and Ceara rubber; the cotton or globular mealy-bug,[10] on cotton, grape, citrus fruit, mulberry and other plants; the citrus or common mealy-bug,[11] which is one of the common, though by no means the only species of the class infesting citrus fruit in the islands.

Other citrus scales worthy of mention are the Florida red-scale,[12] which also infests bananas, mangoes and palm trees, including the cocoanut; the green-scale[13] and two or three other species. The large cottony-scale[14] infests coffee, mangoes, oranges and ferns. The flat black-scale[15] occurs on the banana, fig, pepper tree and Ceara rubber. The hemispherical scale[16] and palm mealy-bug[17] are species found on the palms. Others found on the plants for which they are named are the rose scale,[18] the peach scale,[19] the pepper-tree scale,[20] also found on wild guava; the bamboo scale,[21] the croton scale,[22] the pit or algaroba scale,[23] the cottony-cushion or fluted scale,[24] on the black wattle. The list might easily be extended, but the foregoing will be sufficient

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[2] *Pseudococcus nipæ.* [3] *Aspidiotus hederæ.* [4] *Phenacaspis eugeniæ.*
[5] *Aspidiotus perseæ rum.* [6] *Diaspis bromeliæ.* [7] *Pseudococcus bromeliæ.* [8] *Pulvinaria psidii.*
[9] *Saissetia oleæ.* [10] *Pseudococcus filamentosus.* [11] *Pseudococcus citri.*
[12] *Chrysomphalus ficus = Chrysomphalus aonidum.* [13] *Coccus viridis.* [14] *Pulvinaria mammeæ.*
[15] *Saissetia nigra.* [16] *Saissetia hemisphenica.* [17] *Pseudococcus* sp. [18] *Aulacaspis rosæ.*
[19] *Aulacaspis pentagona.* [20] *Aspidiotus lantaniæ.* [21] *Asterolecanium miliaris.*
[22] *Lepidosaphes pallida.* [23] *Asterolecanium pustulans.* [24] *Icerya purchasi.*

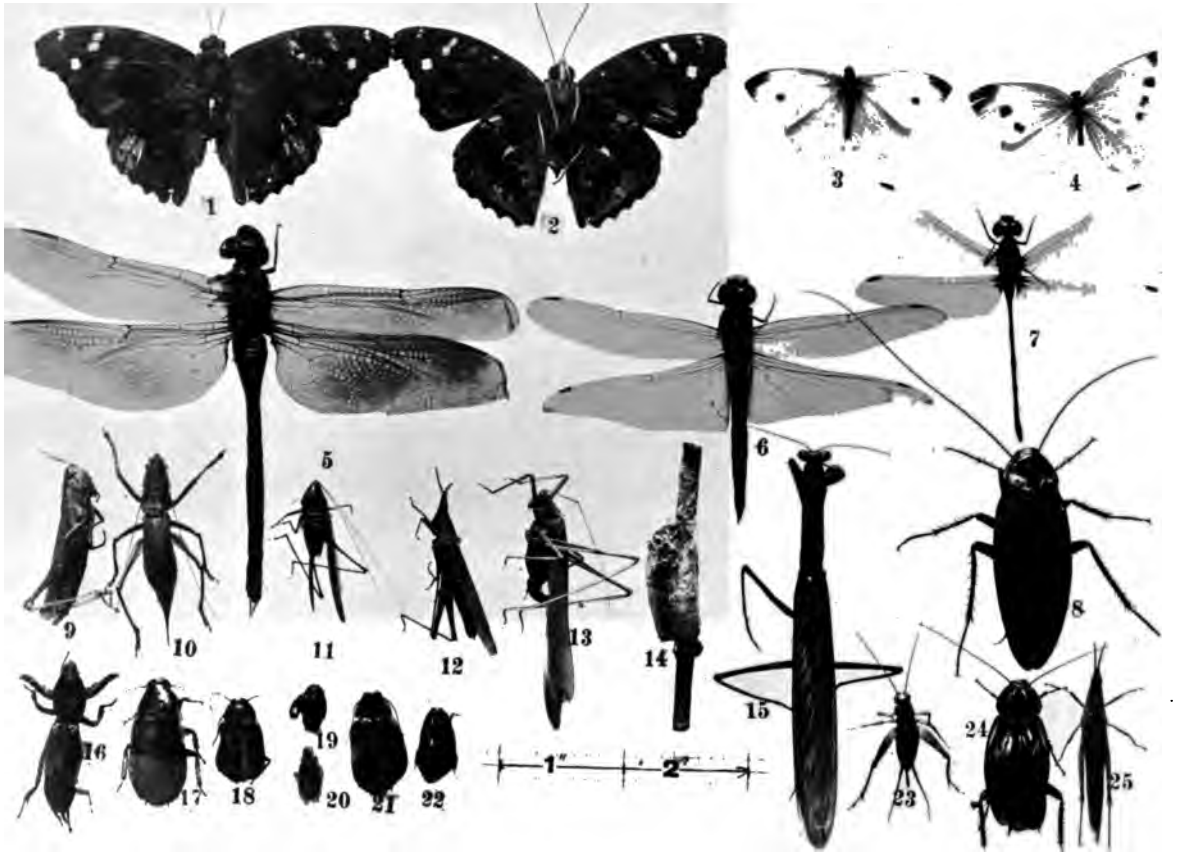

PLATE 97. CONSPICUOUS HAWAIIAN INSECTS.

(For Description of Plate See Opposite Page.)

to show that the scale insect life of Hawaii levies a heavy tax on plant growth in the islands.

Fortunately, the experience of the orange growers of California in their successful attempts at curbing the invasion of a scale [25] which had been accidentally introduced from Australia and had spread with great rapidity, was turned to account in Hawaii. The plan of checking injurious insects by their natural enemies in that State, in the above instance, was so signally successful that Mr. A. Koebele, who was in charge of the work, was induced to come to the islands to put into operation the natural enemy method of warfare which has since won many brilliant battles against the injurious insect pests in the interest of the Territory.

The Ladybird Beetles.

Under Mr. Koebele's guidance, with the aid of his associates, many beneficial insects have been brought to Hawaii from the most remote quarters of the earth. Few, however, have been more generally useful in their habits than those of the ladybird beetle [26] family. The "ladybirds" as they are familiarly known, are small, more or less hemispherical beetles that vary greatly in color, but most often are red, yellow, black or steely blue, and are usually, though not always, mottled or spotted with bright colors. The larvæ are sometimes spotted, but more commonly are marked with warts and spines. There are more than a thousand species, some of which are found in the native fauna of almost every part of the world except Hawaii. As most of the species are predaceous, both in the adult and larval form, and are especially fond of the plant aphids, mealy bugs and scales, their introduction into the islands has been going on steadily for years. A long list has been liberated, and the individuals have established themselves to such an extent that there is scarcely an ornamental plant, fruit or shade tree in Hawaii on which these useful insects cannot be found by a close observer, at some time during the day. The more common species have suggestive, descriptive names that aid the observer in his efforts to identify the insects at sight. Among those easily recognized are the yellow-shouldered ladybird,[27] the ten-spotted ladybird,[28] the vedalia ladybird,[29] which was first successfully introduced from Australia into California to feed on the fluted scale, and from there brought to Hawaii as early as

[25] *Icerya purchasi.* [26] *Coccinellidæ.* [27] *Platyomus lividigaster.* [28] *Coelophora pupillata.*
[29] *Novius cardinalis.*

Description of Plate.

1. Kamehameha Butterfly (*Vanessa tammeamea*). 2. Kamehameha Butterfly (*Vanessa tammeamea*) inverted. 3. Cabbage Butterly (*Pontia rapæ*). 4. Cabbage Butterfly (*Pontia rapæ*) inverted. 5. Dragon Fly (*Anax junius*). 6. *Pantala flavescens.* 7. *Sympetrum blackburni.* 8. *Periplaneta americana.* 9. *Oxya velox.* 10. *Brachymetopa discolor.* 11. *Xyphidium varipenne.* 12. *Atractomorpha crenaticeps.* 13. *Elimœa appendiculata.* 14. *Paratenodera sinensis;* (Egg case). 15. *Paratenodera sinensis.* 16. *Gryllotalpa africana.* 17. *Leucophœa surinanesis.* 18. *Eleutheroda dytiscoides.* 19. *Euthyrrhapha pacifica.* 20. *Phyllodromia hieroglyhica.* 21. *Eleutheroda dytiscoides.* 22. *Eleutheroda dytiscoides;* (Nymph). 23. *Gryllodes poeyi.* 24. *Periphaneta australasiæ.* 25. *Atractomorpha crenaticeps.*

1887; the steel-blue ladybird,[30] the ocherous ladybird,[31] the eight-marked ladybird [32] and the mealy-bug or "Brownie" ladybird.[33]

The Japanese Beetle.

While the ladybirds belong to a family in the order of beetles,[34] and are among the most beneficial members of that great order, they are by no means so typical in appearance as is the injurious Japanese beetle,[35] which is an exceedingly troublesome and aggressive pest in orchards, gardens and dooryards. By reason of its ravenous appetite for the leaves of certain plants, especially roses, foliage plants, strawberries, grapes, cotton, tobacco, certain grasses and a long list of other cultivated trees, shrubs and plants, it is one of Hawaii's worst introduced pests.

They are ordinary-looking, grayish-brown beetles, a little over a half inch in length, with a broad flat head. They are night feeders, hiding by day under the loose earth about the roots of plants and under boards and rubbish. Many attempts have been made to rid the country of this pest since it first became troublesome about 1890. Perhaps the most successful enemy has been a certain fungus that has now been well distributed to all parts of the group. Like all fungi, it is a plant of low order which grows in threads.[36] After a certain period of growth some of these threads "fruit," producing small sacks packed full of minute granules known as spores. The spores are very light and small, and are blown about or carried by birds and insects. Some fungi are injurious, especially such species as grow on the mango and the coffee, but the one in question is beneficial, since it grows in the body of the Japanese rose beetle and, if conditions are favorable as to moisture and so on, it will eventually kill the insect. Dead beetles show the whitish or greenish fungi about the numerous joints of the body and legs. In a few days after death the spores develop and the fungus turns greenish and the disease is then readily communicated from the dead infected insects to healthy ones.

The disease can be easily distributed by simply capturing a supply of beetles and placing them in a secure box partly filled with moist earth. The box should be set in a cool, shady place and the insects fed on any of the weeds or plants of which they are fond. When they die and the greenish mold appears, the dead beetles should be mixed together with dry earth and sand and distributed about the garden or under bushes attacked by the beetles.

Fuller's Rose Beetle.

Fuller's rose-beetle,[37] or the "Maui" or "Olinda" beetle, introduced from America, is an oval black snout-beetle about a half inch in length that, by reason of the extensive range of its food plants of native and introduced species, makes it a serious pest. The only parasite so far a known is the larvæ of a certain click beetle introduced to feed upon it. Toads have doubt-

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[30] *Orcus chalybeus.* [31] *Chilocorus circumdatus.* [32] *Coelophora inæqualis.*
[33] *Cryptolæmus montrouzieri.* [34] *Coleoptera.* [35] *Adoretus tenuimaculatus.* [36] Mycelia.
[37] *Aramigus fulleri.*

less had a beneficial effect, however, and the pest is not so serious as in former years.

Many species of smaller introduced beetles do more or less damage to various cultivated plants or stored commodities. Among the more common, or those liable to attract attention, are the rice weevil,[38] the coffee-bean weevil,[39] the rust-red flour beetle[40] on rice, the sisal weevil;[41] the cadelle beetle,[42] a whitish grub destructive to stored products, as rice; the tobacco leaf-beetle,[43] the carpet beetle,[44] the cigarette beetle;[45] the mango weevil,[46] supposed to have been introduced in 1903; the bean weevil,[47] the common ground beetle,[48] the algaroba bean weevil,[49] and the algaroba pod weevil,[50] both feeding on algaroba beans. In addition there are long-horned beetles of several species on algaroba, black wattle and various other trees, as well as numerous species of bark beetles—but a sufficient number have been enumerated to indicate the nature of the imported pests in this order of insects.

Leaf-Rolling Moths.

Mention has been made of the sugar-cane leaf-roller[51] as an injurious moth belonging to the order Lepidoptera. With it might be considered the cocoanut leaf-roller,[52] which is especially destructive to the cocoanut leaves, and the common banana leaf-roller,[53] one of the four species that infest the banana plants to some extent. All three are native species belonging to a genus of twelve or more species of fair-sized, brown moths that occur in Hawaii and nowhere else, and that are peculiar in their leaf-rolling habits. The larvæ or caterpillar of all species are very similar in appearance, varying in size in proportion to the adult. They feed voraciously on the green leaves during the period of growth and fold the leaf by fastening two portions together with silken threads. When full grown, which requires three or four weeks usually, they change to the pupa within the folded leaf and remain dormant for one or two weeks.

The ragged, unsightly edges on palm leaves, especially of the cocoanut palm, is the result of the work of this leaf-roller. As it is abundant, and the largest species of the genus, it is readily collected and studied. The egg masses, with thirty to eighty eggs in a cluster, are placed along the midrib on the new leaves as they open. As from four to six broods are reared in a year, the work of defoliation continues as rapidly as the palm puts out new leaves. The mynah bird is very fond of the larvæ of the palm leaf-roller and without doubt helps to reduce their numbers.

The bean leaf-roller[54] feeds on several species of native beans, including the wiliwili, and to some extent on garden beans. In feeding they hold the leaves together with a silken thread and eat the inner surface of the leaf, leaving the outer surface undisturbed.

Some of the species of this genus, including the sugar-cane leaf-roller, are

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[38] *Calandra oryzæ.* [39] *Araecesus fasciculatus.* [40] *Tribolium ferrugineum.* [41] *Pseudolus longulus.*
[42] *Tenebroides muritanicus.* [43] *Epitrix parvula.* [44] *Anthrenus scrophulariæ.*
[45] *Lasioderma serricorne.* [46] *Cryptorhynchus mangiferæ.* [47] *Bruchus prosopis.*
[48] *Ompatrum serratum.* [49] *Bruchus prosopis.* [50] *Caryoborus gonagra.* [51] *Omiodes accepta.*
[52] *Omiodes blackburni.* [53] *Omiodes meyricki.* [54] *Omiodes monogona.*

grass feeders, while two species feed exclusively on sedges. The genus ***Omiodes*** have been extensively studied by economic entomologists, who find the caterpillars of the species are attacked by a number of parasites, some of which are native, but several of the most valuable have been introduced. The cane leaf-roller and the palm leaf-roller are the two most injurious species. The parasites do much good, but at certain seasons, especially in winter, and in certain localities the caterpillars get the start of their enemies, and one or two broods appear before parasites are abundant enough to check them.

Sometimes as high as ninety per cent of the caterpillars are found to be parasitized. One might ask, "Why are they not completely exterminated or, at least, why do they continue to do so much damage?" The answer seems to be that, although they have many enemies that prey upon them, they are still prolific enough to overbalance their enemies. It is difficult to estimate the damage they would do were they entirely free from their burden of parasites.

Cutworms.

Cutworms of various species are a serious agricultural drawback, as they attack corn, tobacco, cotton, cabbage, wheat and other useful plants, nipping the young plants off at the surface of the ground before they have fairly started. There are several species of these night marauders, but they all belong to a family of owlet moths or Noctuids *(Noctuidæ)*, one of the largest groups of the order *Lepidoptera*. They feed at night in the larval stage and fly by night in the adult stage, often being attracted by lights. The fact that their eyes shine brighly in a dim light and that they are seldom seen in the daytime has resulted in the popular name for the adults, while the unfortunate habit of the larvæ has given them the unenviable name of cutworms. The species are mostly small-sized, dull-colored moths. The most troublesome species in Hawaii are the widely-known and doubtless introduced black or corn cutworm [55] with the hind wings greenish; and a second species, a large native cutworm,[56] with fuscous-colored hind wings, both being plentiful on corn and other field crops. A third species known as the small native cutworm [57] is also common. They are kept in check in Hawaii to some extent by their natural enemies, which include both parasites and birds, but as there are two or three dozen native species, the caterpillars of all of which resemble each other and have similar habits, it is difficult to identify the spices that feeds on the various crops and weeds, even when adult specimens are secured.

Army-Worms.

The widely-known army-worm,[58] with its cousins the grass army-worms,[59] at times do much damage to grass and forage crops. They appear in great numbers occasionally, and after destroying the vegetation in the field where

[55] *Agrotis ypsilon* [56] *Agrotis crinigera.* [57] *Agrotis dislocata.* [58] *Heliophila unipuncta.*
[59] *Spodoptera mauritia* and *Spodoptera exigua.*

they hatch from the eggs, they march like an army to other fields. The worm of the common species, which occurs in America and elsewhere, is an inch and a half in length when full grown and is striped with black, yellow and green. The adult moth is dull brown in color, marked in the center of each fore-wing with a small distinct white spot. The two species of grass army-worms occurring here are widely distributed, especially in the Pacific islands and continents.

The Hau Moth.

The hau moth [60] is also a wide-ranging species occurring in Africa, south Asia and Fiji. It can scarcely be separated by the layman from another more local species. However, as it confines its depredations quite closely to the hau and allied plants, it can be recognized as the small brown moth which develops from the caterpillar that feeds so voraciously on the leaves of that picturesque tree. Its principal enemy is an ichneumon fly that destroys them by depositing its eggs in the body of the caterpillar.

Loopers.

Several species of measuring worms or span worms, belonging to the family *Hydriomenidæ,* occur in the islands. The koa is often attacked by them and the trees seriously defoliated, but so far as known they are not a serious economic pest. A species of the group *Plusiadæ,* known as the corn looper,[61] or green garden looper or owlet moth, attacks wheat and corn and other plants, often fraying the leaves to a considerable extent.

The larvæ of the kolu-bush moth [62] are to be found in the pods which follow the beautiful little golden ball-like blossoms. They feed upon the seed and doubtless keep this thorny shrub from spreading as rapidly as it otherwise would.

The Silkworm.

An exceedingly useful insect, long ago introduced into Hawaii, is the silkworm.[63] The first specimens were imported by the missionaries with a view to encouraging the natives to take up this form of productive occupation. The experiment was given up, however, before anything definite came of it. Some say that the pious and faithful observance of the Sabbath as taught by the Christian fathers prevented the natives from gathering the fresh leaves to feed the worms on that day.

More recent experiments have proved beyond a doubt that silk of a good quality can be produced in Hawaii with as little effort as in any silk country in the world. The mulberry, especially the white mulberry,[64] does well in Hawaii. As the leaves of this plant are the favorite food of the worms, it is anticipated that silk culture will yet flourish in the islands as one of the home occupations for the employment of women and children.

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[60] *Cosmophila sabulifera.* [61] *Plusia chalcites.* [62] *Cryptophlebia illepida.* [63] *Bombyx mori.*
[64] *Morus alba.*

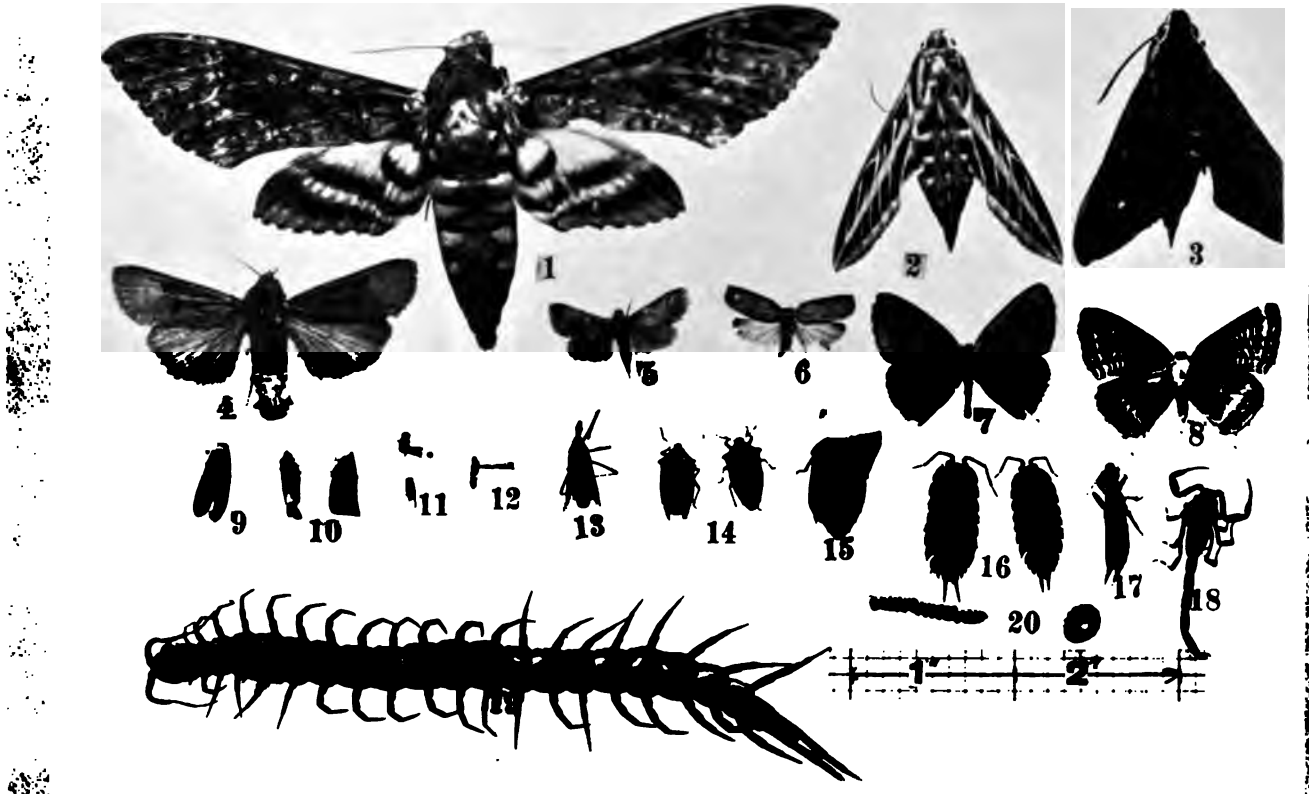

PLATE 98. SOME COMMON INSECTS AND THEIR RELATIVES.

(For Description of Plate See Opposite Page.)

The newly-hatched larvæ of the silkworm is black or dark gray and covered with long, stiff hairs. But as the worm moults it becomes lighter and lighter in color until during the last of the larval period it is creamy white. The cocoon is spun by the worm about itself as a protection and a retreat in which to pupate. It ranges in color through several shades of white, green cream and rose, and varies greatly in size. To secure the silk the cocoons are heated in water or in an oven until the insect is killed; the end of the thread is then secured and the cocoon unwound. The adult insect is a beautiful creamy white moth with two or more distinct brownish lines across the fore wing, and with the abdomen and thorax thickly covered with wooly scales.

From two to three thousand years before the Christian era, probably five thousand years ago, the silkworm was well and favorably known in the Far East where, in China, silk culture was a well-established industry.

The Cabbage Butterfly.

The slender green cabbage-worm in due time becomes a cabbage-butterfly,[65] and is the white butterfly commonly seen about gardens in the islands. It was doubtless introduced from America, where it has long been an introduced pest. It was first observed in the islands about 1900, and is therefore known as the imported cabbage worm. The species is kept under control in Hawaii by parasites, among them a very minute fly.[66]

The Sweet Potato Horn-Worm.

A conspicuous insect, liable to attract attention, first in the larval state, as the large green or brownish horn-worm on sweet potato, and certain morning-glory vines, and later as the humming-bird moth that flies about our electric lights, is in reality the sweet potato sphinx-moth or sweet potato horn-worm.[67] The worm-like caterpillars often attain a length of three or four inches and are voracious feeders, stripping the leaves from the plants infested. The moth, by reason of its size and the whirring noise produced by its wings, is usually called the humming-bird moth. It measures about three and a half inches across the extended wings, and is the largest common moth in the islands.

The Cotton Boll-Worm.

The cotton plant in Hawaii, if it successfully survives the attacks of stem maggots, wireworms, cutworms, aphids, Japanese beetles, mealy bugs, scales and leaf-rolling caterpillars is liable at last to the attacks of the pink cotton

[65] *Pieris rapæ.* [66] *Tachinid.* [67] *Protoparce = (Sphinx) convolvuli.*

Description of Plate.

1. Sphinx, or Humming-bird Moth (*Sphinx convolvuli*). 2. *Deilephila lineata.* 3. *Deilephila calida.* 4. *Agrotis crinigera.* 5. *Pyralis mauritialis.* 6. *Amorbia emigratella.* 7. *Lycæna boetica.* 8. *Lycæna boetica* (inverted). 9. *Ethmia colonella.* 10. *Siphanta acuta.* 11. *Perkinsiella saccharicida.* 12. *Peregrinus maidas.* 13. *Zelus renardii.* 14. *Œchalia grisea.* 15. *Coleotichus blackburniæ.* 16. Slater or Pill-bug (*Porcellio scaber*). 17. *Anisolabis annulipes.* 18. Scorpion (*Isometrus maculatus*). 19. Centipede (*Scolopendra rapens*). 20. Millipede (Species indet.).

boll-worm,[68] which is by far the most destructive enemy of the cotton plant. There seems to be no doubt but that it was introduced directly or indirectly from India within comparatively recent times. It does the damage in the caterpillar stage, when, as its name implies, it attacks and feeds on the lint and seed of the cotton in the ball before it is open, practically destroying the boll so far as its lint is concerned. The moth is about three-fourths of an inch across the expanded wings, and is soft gray-brown in color, with darker markings; the fringe on the hind wings being wider and paler brown than on the front wings.

Lice.

The various flies that annoy human beings and their domestic animals have been briefly mentioned above, but other introduced animal pests occur and are as troublesome here as elsewhere. Among them are a number of species of lice. The term "lice" is loosely applied to representatives of two orders of insects. Those occurring on poultry and wild birds are properly called bird-lice,[69] although some species infest sheep and goats also. They are wingless parasitic insects with biting mouth-parts enabling them to feed upon and live among the bird's feathers. The turkey-louse[70] and the chicken-louse are examples of this class. The family *Pediculæ*, including the true lice, belongs to a sub-order[71] of the great order *Hemiptera* and includes certain parasites of man and other animals. They differ from the bird-lice in having sucking mouth-parts. They live among the hair of their host animal, feeding on its blood. Three species are known that are parasitic on man; one lives in the hair on the head[72] and two, a body louse[73] known as the "gray-back" and the crab-louse,[74] on the body. While the more common species elsewhere are those found on the horse or a second species occurring on the cow, they have not as yet been reported in Hawaii. Almost every animal has a species of louse, though they are not always attached to all host animals. The hog-louse,[75] for example, is reported as occurring here in limited numbers, while other species doubtless to be found here have not yet been taken.

Ticks and Mites.

It should be mentioned in this connection that ticks are often confused in the popular mind with lice, although they more properly belong with a distinct division of the branch[76] of the animal kingdom which includes the insects, spiders, scorpions, centipedes, crabs and lobsters. In all of these the body is composed of a series of segments joined together, with some of the segments bearing jointed legs. In the order[77] to which the mites and ticks belong the abdomen is unsegmented and is united to the thorax, giving the body a sack-like appearance.

The order including the mites is represented in Hawaii, but as yet only

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[68] *Gelechia gossypiella.* [69] *Mallophaga.* [70] *Goniodes stylifer.* [71] *Parasita.* [72] *Pediculus capitis.*
[73] *Pediculus vestimenta.* [74] *Phthirus pubis.* [75] *Hæmatopinus urius.* [76] *Arthropoda.*
[77] *Acarina.*

nine species, all belonging to one family,[78] have been determined, six of which are already known from the British Isles. But as the largest species[79] is but a millimeter in length and has only been reported from Kona, on Hawaii, they are too small to attract attention from collectors. As they occur, however, it is well to know that the common species[80] appears to be generally distributed throughout the mountains of the group.

Most of the ticks are small eight-legged creatures, though the number of legs vary with age and the mode of life of the parasite. The chicken mite is an example that occurs in Hawaii on poultry; the dog-tick[81] on the dog; the so-called red spider[82] occurring on cotton plants, and the true itch mite,[83] causing an irritation of the skin of human beings known as itch, are well-known examples of the species of the order.

Fleas.

The flea is a tiny insect belonging to the order *Siphonaptera*, and is suggestive of the household pests of which Hawaii has its full quota. As has been the case with the insects affecting the field, forage and garden plants and our domestic animals, the household pests have practically all been introduced since the islands were discovered. Fleas were among the early arrivals, and may be said to abound in certain localities, especially dry elevated places. The native name (Ukulele) for a "jumping louse" was early applied to this tormenter, which is one of the few insects it is not necessary to see in order to identify. While they occur about houses and bite the inmates and their pets, the species most commonly captured are the cat-flea or the dog-flea,[84] though the comon human species[85] doubtless occurs.

Plague Carried by Fleas.

One of the many brilliant medical achievements for which the closing years of the last century were especially noted, was the discovery that the flea that lives on the common rat is responsible for the spread of the dread bubonic or black plague. It has been proved over and over again that rats die of this disease and that the fleas which infest them and feed on their blood draw the minute organism causing the disease into their bodies in such a way that they can communicate the plague to other rats and to other animals, among them man, by their bite. Cases are on record where death from plague has been traced to its origin only to find that it came from flea bites. Fleas usually leave the carcass of a rat that has died of plague and at the first opportunity take up their abode on some living animal, as the cat or dog. From these pets they are easily transferred to their masters, with the result that their bite may convey the minute microscopic organism[86] that causes plague in the human body. Plague has appeared on more than one occasion in Hawaii,[87] and to all appearances has been successfully stamped out. Nevertheless, it is well for

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[78] *Oribatidæ.* [79] *Oribata oriformis.* [80] *Neoliodes theleproctus.* [81] *Rhipicephalus sanguineus.*
[82] *Tetranychus* sp. [83] *Sarcoptes scabei.* [84] *Ctenocephalus canis* = *Pulex canis.* [85] *Pulex irritans.*
[86] *Bacilus pestes.* [87] Notably during the winter of 1900.

people living in the tropics to rid their premises of rats and to keep at respectful distances from pet animals that may feed upon them.

Cockroaches.

Mosquitoes and flies as domestic pests have been mentioned as members of the order *Diptera,* and have been discussed in another connection. Cockroaches, of which there are several introduced species, are annoying pests. Two species, the American [88] and the Australian [89] cockroach, are both found in houses, most commonly infesting kitchens and pantries, attacking provisions of all kinds besides doing much damage to book bindings in the library. They emit a disgusting smell and are otherwise objectionable to everyone. They resemble one another very closely, but vary in color and appearances as they develop. The American species is about two inches in length, the latter a trifle smaller.

Bedbugs and Other Bugs.

The bedbug,[90] as everyone knows, is a nocturnal insect. It occurs the world over and, therefore, is occasionally found in Hawaii. It seems that, although it has very rudimentary wings, it has nevertheless been able to keep up with the march of human progress. They have certain characteristics that make them members of the order of true bugs.[91] In the same order are placed the torpedo-bug,[92] a green-winged, long, pointed leaf-hopper, injurious to mangoes, guava and coffee, and the more attractively-named Hawaiian kissing-bug,[93] which in reality is the common assassin-bug that first appeared in the islands about 1897. Since then, contrary to the character its local name seems to imply, it has maintained a reputation as a fierce carnivorous bug, feeding among other things, on ladybirds, leaf-hoppers and aphids, without discrimination between the beneficial and injurious insects.

White Ants.

The termites, more commonly termed white ants,[94] that at certain seasons fly about in large swarms and at all seasons bore into the timbers of houses, are not ants, nor are they more than remotely related to the true ants. They have been placed by many entomologists, by reason of all four wings being equal in size, form and structure, in a separate order.[95] It is true that they have certain social habits that are similar to the ant's, but their structure is very different, as anyone can see by comparing the two insects. Their communities are made up of many individuals that have a definite part of the colony work to do. Each class is fitted by nature with special reference to the task it must perform. Kings, queens, soldiers and workers live together in their many-chambered nests. Their nests are hollowed out of the timbers in which they carefully eat out the interior, leaving an outer shell in such a

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[88] *Periplaneta americana.* [89] *Periplaneta australasiæ.* [90] *Cimex lectularius.* [91] *Hemiptera.*
[92] *Siphanta acuta.* [93] *Zelus renardii.* [94] *Calotermes marginipennis.* [95] *Isoptera.*

manner as to exclude the light. In this hidden way they do a great many thousand dollars' worth of damage to houses in Hawaii every year. In some cases the heart of the timbers that formed the building have been so badly eaten that in time the structure has actually fallen in pieces, leaving only a sad heap of ruins as a monument to the silent industry of these destructive creatures.

Silverfish.

Silverfish, fish-moths, or bristletails[96] are everywhere household pests, and Hawaii is not an exception. The small, flat, silvery object without wings that scurries out of sight in the dresser drawer or on the book-shelf is sure to be one of these evildoers that cannot resist the taste of starch, no matter whether it be in clothing, book-bindings or wall-paper. In structure the silverfish represents the simplest type of insects, and is peculiar for the reason that it does not go through any marked changes[97] as it develops. It is therefore placed by entomologists in the lowest, meaning the oldest and most simple, order[98] of insects.

Ants.

As types of the highest development and specialization in the insect world, the ants, bees and wasps are placed together in a great order[99] at the opposite end of the scale from that occupied by the silverfish. The ants, the bees and the wasps each furnish the housewife one or more pests to annoy her. Of these, the ant family[100] furnish a number, the most troublesome being the cosmopolitan big-headed ant[101] that invades every nook and corner of the house and considers the food-safe and ice-box as institutions especially provided for its comfort and convenience. They will not cross water, however, so the experienced housewife places the legs of the ice-box in shallow cups filled with water and takes pains to keep the box clear of the wall. The table, safe and sideboard can be equally well protected for months at a time by tying about each leg a narrow strip of woolen cloth, which has been soaked with "ant poison," a preparation sold by the druggist for the purpose. The ants respect the poisoned string as a dead-line and rarely pass beyond it. Another common species is the big brown ant[102] observed swarming on warm, still nights, when all forms issue in great numbers.

Carpenter-Bees.

Of the bees, the blue-black carpenter-bee,[103] which resembles the bumble-bee in size and somewhat in appearance, is conspicuous and troublesome in Hawaii by reason of its habit of building its cells in the solid wood of trees, porch posts, fence posts, telephone poles and the like. It often excavates a tunnel a foot or two in length in which it lays its eggs. Each egg is contained

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[96] *Lepisma saccharina.* [97] Metamorphosis. [98] *Thysanura.* [99] *Hymenoptera.* [100] *Formicina.*
[101] *Pheidole megacephala.* [102] *Camponotus maculatus*, var. *hawaiiensis.* [103] *Xylocopa brasilianorum.*

in a separate compartment provisioned with bee-bread—a food made of the pollen from flowers mixed with nectar. It has been observed that they gather their supply of pollen principally from the bean-like plants. This bee was introduced long ago and is widely distributed throughout the group.

Wasps and Mud-Daubers.

Of the wasps, the species known as the mud-dauber,[104] a species introduced from America, is the one causing the most annoyance about the home. It makes its nest of mud, which it delights in plastering under the eaves of houses, on the ceilings of lanais, and in similar places. Their nests usually have the form of several tubes an inch or more long placed side by side, which are always provisioned with spiders. This family of wasps[105] is known as the thread-waisted wasps, an allusion to the peculiar shape of the body. They have a curious habit of jerking their wings frequently in a nervous manner, which is also quite characteristic.

The paper wasps[106] are those that build their nests in a single circular comb suspended by a slender central support from the under side of the rafters, or from under the leaves of bushes in the yard and garden. Three closely-related species are quite common in Hawaii, but the bright yellow species[107] is the most savage; the browner species[108] is said to be less so. Children soon learn to respect the rights of these "yellow jackets," as they are commonly called, and never forget the lesson usually learned at first hand from disturbing one of the gray paper nests that are so zealously guarded by the wasp inmates against all who venture to intrude on their domain.

If unmolested, however, the little colony will sit for hours at a time on their paper home without attempting to sting anyone. After the young have grown up they abandon the nest but remain about here and there until the following February, when they organize for business and proceed to make a new nest, securing the silver-gray "pulp" used in its construction from fence-posts, boards and dead wood generally.

The Honey-Bee.

The honey-bee,[109] although not a household insect, is so intimately associated with our domestic life that it may not be out of place to direct attention to it as representing the highest group of the most exalted order of insects. As an example of social life among insects, bees have been studied by naturalists for centuries, until there is probably no other insect of which man has such an intimate acquaintance. They furnish a subject of interest about which fascinating volumes have been written, and afford an ever-present object-lesson in community life among our insect friends. By reason of their useful products they have long been of great economic importance to man. In Hawaii alone the annual output of honey is valued at tens of thousand of dollars.

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[104] *Sceliphron cæmentarium.* [105] *Sphegidæ.* [106] *Vespidæ.* [107] *Polistes hebræus.* [108] *Polistes aurifer.*
[109] *Opis mellifica.*

The Clothes-Moth and Other Household Pests.

The clothes-moth [110] is the dread of every housewife, and any harmless little moth that ventures indoors by accident or otherwise is usually condemned to instant destruction lest a single guilty one should escape. Practical experience has proved this to be the best rule to follow. At any rate, a moth that seeks out the dark corners of the closet and bureau drawers and hides itself away in clothing is not to be trusted, nor should such places of concealment to be long neglected for fear the adult moth that is killed has already deposited her eggs. From the eggs of the clothes-moth in due time will emerge the characteristic brownish-black voracious caterpillar that feeds on the fabric and also uses the material for the construction of the husk-like case in which it assumes the chrysalis state.

Besides the clothes-moth to annoy the housewife there is the closely-related angoumois grain-moth [111] that attacks stored rice. Other enemies that occur in stored products and supplies in Hawaii are rice-weevils,[112] bean-weevils,[113] red-rust flour-beetles,[114] ham and cheese maggots,[115] bamboo beetles,[116] bone-meal beetles,[117] bakery beetles,[118] cigarette beetles,[119] and the cadelle or meal-worm,[120] a small beetle that is world-wide in its distribution.

Centipedes.

While discussing the more familiar household insects, allusion should be made to several other small creatures that, although they are not insects, belong with the insects to the great branch *Arthropoda*—a group that, as we have seen, has been made to include all such creatures as have bodies composed of a linear series of rings or segments bearing paired, jointed appendages that are articulated with an external skeleton.

The common venomous centipede [121] is an example of the *Chilopoda* that may be recognized at a glance by the fact that each segment of the body bears a single pair of legs. The poison glands open through the claws of the first pair of legs. These are bent forward so as to act with the mouth parts. While the bite of a centipede in Hawaii is extremely painful, as many can testify, it is not dangerous, and may be counteracted by the use of ammonia, or it is said that, in the absence of that chemical, relief may be had by pounding the centipede itself into a jelly-like mass and binding it onto the bite. A centipede bite may be at once identified from the sting of any other creature by the fact that the pincer-like legs make a pair of punctures in the skin of the person "bitten." The distance between the punctures furnish a fair index as to the size of the specimen inflicting the injury.

Centipedes are predaceous in habit, feeding on insects generally, but especially on cockroaches. They usually live in moist, dark places under sticks, boards, stones, and in crevices in the bark of trees during the daytime,

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[110] *Tinea pellionella.* [111] *Sitotroga cereatella.* [112] *Calandra oryza.* [113] *Bruchus obtectus.*
[114] *Tribolium ferrugineum.* [115] *Piophila casei.* [116] *Dinoderus minutus.* [117] *Dermestes cadaverinus.*
[118] *Lophocateres pusilla.* [119] *Lasioderma serricorne.* [120] *Tenebrioides mauritanicus.*
[121] *Scolopendra repens.*

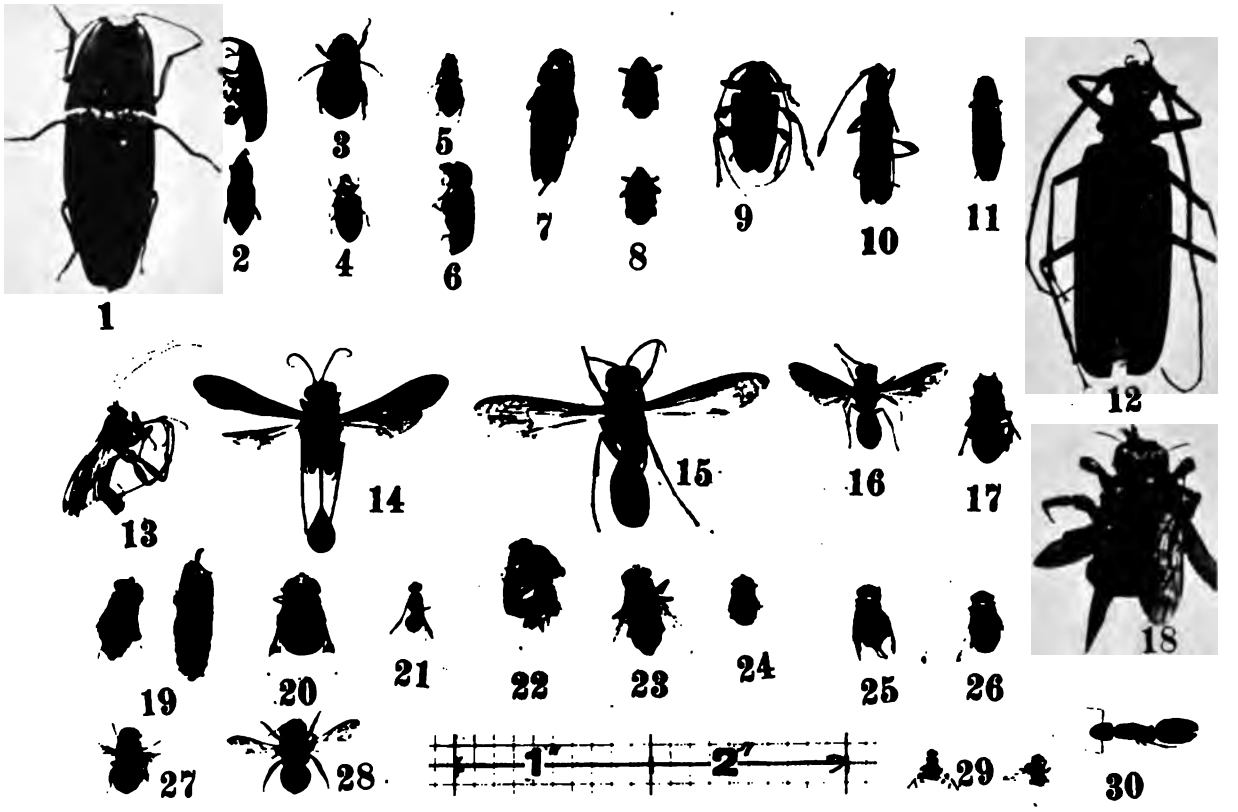

PLATE 99. COMMON BEETLES, BEES, WASPS, FLIES, ETC.

(For Description of Plate See Opposite Page.)

but at night they become active and race about rapidly in search of food. They are most troublesome in houses during the long wet spells, for, while they naturally prefer moist situations, they come out of the ground and enter dwellings and outhouses when their ordinary hiding-places become water-soaked.

Centipedes five inches or more in length are not uncommon, and larger specimens are occasionally seen. The large species was introduced as early as 1836, and there has been at least one other small species introduced since.

The young centipedes have a curious habit of clinging to their mother's side when alarmed. The female lays her eggs in clusters on the damp ground in some obscure place, and, coiling herself round them, remains immovable until the young have hatched.

The largest centipedes known come from the East Indies, where they grow to be a foot in length. The centipedes[122] of the Hawaiian Islands have not been exhaustively studied as yet, but all of the species so far recorded belong to genera that occur elsewhere. Four species belonging to three families were collected in the Hawaiian mountains by Dr. Perkins, three of which are described as new in the Fauna Hawaiiensis.

Scorpions.

At least one introduced species of scorpion[123] is quite common in Hawaii, where specimens frequently attain a length of three inches. The large species of the order[124] occurs in tropical Africa and southern India, where a certain big black scorpion may attain a length of eight or nine inches. The poison sting is located in the tip of the long slender tail, which is carried curled in a menacing fashion over the back.

When the scorpion comes in contact with any creature suited to its taste as food it will seize it in the vise-like grip of the pincer claw. The tail is brought into use and the sting on its tip is plunged into its prey. Small animals, insects and the like as a rule quickly succumb to the paralyzing effect of the poison. As the scorpion has no antennæ to use as feelers, it always carries its pincers well to the front.

Scorpions are night feeders and are exclusively carnivorous, feeding mainly on small insects; silverfish, moths and caterpillars being among their favorite food. Unlike the centipede, they prefer dry, dark places, and for that

[122] *Chilopoda.* [123] *Isometrus maculatus.* [124] *Scorpionida.*

Description of Plate.

1. *Chalcolepidius erythroloma.* 2. *Rhabdocnemis* = (*Sphenophorus*) *obscurus.* 3. *Adoretus tenuimaculatus.* 4. *Epitragus diremphus.* 5. *Aramigus fulleri.* 6. *Bostrichus migrator.* 7. *Clytus crinicornis.* 8. *Cryptorphynchus mangiferæ.* 9. *Coptops ædificator.* 10. *Xystrocera globosa.* 11. *Simodactylus cinnamomeus.* 12. *Ægosoma reflexum.* 13. *Echthromorpha maculipennis.* 14. *Pelopæus cæmentarius.* 15. *Polistes hebræus.* 16. *Odynerus nigripennis.* 17. *Apis mellifica.* 18. *Xylocopa braziliensis.* 19. *Chætogædia monticola.* 20. *Volucella obesa.* 21. *Dacus cucurbitæ.* 22. *Gastrophilus equi.* 23. *Sarcophaga barbata.* 24. *Calliphora dux.* 25. *Lucilia sericata.* 26. *Lucilia cæsar.* 27. *Anthomyia sp.* 28. *Megachile diligens.* 29. *Ceratitis capitata.* 30. *Camponotus maculatus.*

reason are much more liable to be found in bureau drawers, in loose papers and litter, in empty boxes and similar places about the house. When first born the tiny scorpions closely resemble their parent. They cling to her body and are carried about for a long time before they begin to shift for themselves. The sting of the species occurring in this group of islands is not dangerous, though it may be very painful for a few hours.

The false scorpions[125] are also represented by four minute species, two of which are described from Hawaii. The largest species[126] is about five millimeters in length, and, as the name of the order implies, it bears a superficial resemblance to the scorpion.

Millipeds.

The natural order,[127] including the so-called thousand-legged worms or millipeds, is well represented in Hawaii. The largest species,[128] which is about two inches in length when full grown, is a comparatively recent introduction, coming presumably from California. So far, it has been reported only from the vicinity of Honolulu, where the sluggish, dark, reddish-brown creature may be seen curled up in damp places, under boards, flower-pots or, less frequently, crawling along the road in the early morning. They differ from the centipede in having the body round instead of flattened and they are also provided with two pairs of legs for each segment of the body. However, the total number of legs falls far short of a million. They are perfectly harmless and may be handled without fear. Their food seems to be vegetable matter, such as tender roots, fruits and succulent plants, and perhaps any decaying organic matter.

The class *Diplopoda*, so far as it has been studied in Hawaii, is represented by at least sixteen species belonging to five families and four orders. Of this list fourteen are described as new and about one-third of the number recorded occur on Oahu. Two introduced species, one the large worm-like milliped mentioned above, and the second a smaller tan-colored animal with two brownish stripes down the sides, are commonly met with. They have the power of emitting a curious characteristic odor. The other members of the class are usually confined to the mountain forests, and are probably peculiar to Hawaii.

Sow-Bugs or Slaters.

The curious little oval silver-gray creature found in large numbers in damp places, under boards and stones, is usually an introduced species known to many as the pill-bug, slater, sow-bug or wood-louse.[129] But of the order *Isopoda* there are nine of ten species belonging to five genera, in the islands, several of which are native. The minute armadillo-shaped arthropods of this order occurring at higher elevations on the islands closely resemble the more common widely-distributed species. Their positive identity, therefore, requires more than casual observation. All of the species are nocturnal in habit and unless

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[125] *Pseudoscorpiones.* [126] *Chelifer hawaiiensis* [127] *Diplopoda.* [128] Sp. undet. [129] *Porcellio scaber.*

disturbed are not seen in the daytime. Decaying vegetable matter is supposed to furnish them with their principal supply of food.

Sand-Hoppers.

The species of sand-hoppers belong to a family [130] in the order *Amphipoda,* to which order also belong the fresh-water shrimps. By some they may be mistaken for the pill-bug. Though they are distantly allied to the pill-bug, since they are true crustacea, they are easily identified as belonging to a different family, as they have the body narrowed and flattened from side to side, instead of broad and flat, and all proceed by a hopping movement when alarmed. The common sand-hoppers live near the edge of the sea and are aquatic in habit. There are species, however, which are found high up in the mountains in damp situations and in the cups at the base of the leaves of a number of plants such as the ieie vine, ki plant and in similar places. Three species belonging to two genera have been reported from the mountains of Oahu, and there are doubtless species occurring on all the islands of the group.

Spiders, Mites and Ticks.

Zoölogists usually place the spiders together in an order [131] of the Arthropods, where, with certain other orders, including such animals as the scorpions, the harvest-men or "daddy-long-legs," the mites and ticks and similar creatures, they unite to form a class.[132] This class is made up of several well-marked orders, but the spiders are generally taken as the type for the group, as they show clearly the difference between the class to which the insects [133] belong, and the class which they represent. There are several important characteristics common to the spiders, among them the possession of eight legs, the absence of antennæ or feelers, and the division of the body into two main divisions,[134] that at once separate them from the insects, which have, as a rule, six legs, antennæ and the body divided into three parts, namely, the head, thorax, and abdomen.

House-Spiders.

While there are more than a hundred species of spiders in Hawaii, many of them spinning webs, they are for the most part so small and inconspicuous that they rarely attract the special notice of the housewife. The jumping-spiders [135] and the big brown house-spider,[136] a member of the family of hunting spiders,[137] and the well-known garden spider should, however, be mentioned as exceptions to the rule.

The jumping-spiders are small or medium size with a short blackish body and short stout legs. They occur on plants, fences and about houses, and attract attention by their peculiar appearance, bright marking and quick-jumping movements that differ from those of the web-weaving and hunting

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[130] *Talitridæ.* [131] *Araneida.* [132] *Arachnida.* [133] *Insecta.* [134] The cephalothorax and abdomen.
[135] Family *Attidæ.* [136] *Heteropoda regia.* [137] *Clubionidæ.*

families. Since they spin no webs to annoy one, their comical stare and knowing ways in a measure make up for the stinging bite they can administer when their liberty is interfered with.

The garden-spider[138] is doubtless an importation. It is the large species, with the abdomen conspicuously marked with creamy yellow and black, that occurs in the shrubbery about the house and garden, where it makes its bulky, oddly-woven nests. It is common from sea-level up to 4000 feet elevation, and is also found in America and Australia.

The big brown spider[139] or house-spider is often three or four inches across, and to the tourist, at least, they present a most formidable appearance. They are common in houses all over the islands, as well as in all tropical countries, and are often looked upon as household pets. They are perfectly harmless. In many families their long residence and evident appreciation of friendly attentions from the members of the household has given them an enviable place among the domestic pets. They feed on cockroaches, moths, flies, silverfish and other insects, in an evident desire to be useful as well as interesting, and seldom leave their accustomed resting-place during the daytime. At night they become alert and active in search of food. As they never spin webs, the mother spider is forced to carry the white lozenge-shaped egg-sack about with her between her legs until her eggs have hatched. Mr. E. M. Ehrhorn found that it required about thirty-five days for the young spiders to hatch and leave the egg-sack, and that 197 out of 207 eggs hatched.

The Hamakua Spider.

An investigation of the habits of spiders found in the cane fields, at the time of the leaf-hopper outbreak already referred to, resulted in finding that out of the one hundred and five species of spiders recorded in the islands, at least twenty occur in the cane fields. However, only fourteen species were found feeding on insects infesting the cane. The most useful species[140] in the cane fields is variously known as the Kohala spider, the Hamakua spider and the Puunene spider. In some sections it is very abundant, so that as many as fifty of its roundish white nests have been found on a single leaf of cane.

Some of the species met with in the mountains spin very large, firm webs. It is not uncommon to find these stretched across the path, suspended on strong stay threads twenty-five feet or more in length. As a rule, however, the species peculiar to Hawaii are not conspicuous in size or habit, the great majority being less than five millimeters in length.

CHAPTER XXXII.

NATIVE INSECTS.

In the foregoing chapters some of the more important injurious insects have been passed in review. We now turn to consider some of the salient fea-

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[138] *Argiope avara.* [139] *Heteropoda regia.* [140] *Pagiophalus atomarius.*

tures of the native fauna, since it is one of considerable general as well as biologic interest.

Character of the Native Fauna.

The number of species even in the limited and precinctive area of the islands is so great that it is not possible to do more than indicate in the briefest way the character and extent of the various orders represented in the group, and to assure those who take especial interest in the subject of entomology that they will find in Hawaii an extensive literature already prepared and an interesting field before them for study and investigation.

The stranger in the islands, with only a few days to spend in the collecting of specimens, is fortunate in that two of the most favorable localities for gaining a bird's-eye view of the native insects in their native environment, are also two of the most accessible. They are the mountains back of Honolulu, particularly the higher slopes of Tantalus, and the region in the vicinity of the Volcano Kilauea, on Hawaii.

Dr. Perkins, the veteran naturalist of the islands, whose active life in the field of entomology has been largely spent in bringing together the material on which a monumental work, in three volumes, known as Fauna Hawaiiensis is based, has published short papers[1] setting forth briefly the more important and interesting forms that may be met with in the localities mentioned. These succinct papers will serve the collector as a field guide to each locality and aid him in his search for the rarer forms to be found in these favored precincts.

The student will early learn to appreciate the importance of careful and intensive study of circumscribed localities, since each island, valley, mountain, and even limited areas and often certain peculiar plants, have their peculiar forms. It will also be noted that such influences as elevation, moisture and dryness play important parts in the distribution of species and the establishment of their vertical and horizontal range.

Insects Occurring on Mamaki.

The work on the life histories of various groups of Hawaiian insects that has been carried on by the individual members of the local Entomological Society has added material of the greatest interest to our increasing store of knowledge concerning the habits of the native insect fauna. This is especially true in the group of *Lepidoptera*, wherein Professor Otto Swezey, in his study of moths and butterflies, has done much to clear up many obscure relations existing between that order of insects and those insects preying upon them in their early stages of development. The bearing of these inter-relations in their effect on the native vegetation has often proved to be of great biologic interest.

In his investigation of the insects associated with the mamaki (a native Hawaiian shrub, from which kapa was formerly made), he has indicated the

[1] Insects of Tantalus, Perkins, Proc. Haw. Entom. Soc., Vol. I. pt. 2, pp. 38-51. Insects of Kilauea, Perkins, Proc. Haw. Entom. Soc., Vol. I, pt. 3, pp. 89-99.

way to a field of fascinating and practical study that others, not wholly consumed with the desire to add new species to the fauna, nor equipped for serious systematic research, will find of value and interest.

During a period of two or three years in connection with other field collecting, mostly confined to the Island of Oahu, he gathered and studied material from which he reports the taking of more than seventy-five insects and their parasites from this single species of plant. He enumerates nine species that appear to be found on mamaki and on no other plant. Thirteen species feed extensively on its leaves, one bores into the green twigs and one lives on the bark. Of those attacking the dead or dying shrub, eighteen occurred in the trunk and branches, and two feed on fungus, on or beneath the bark. The insects which visit mamaki in search of prey were divided into five species of *Coleoptera*, four species of *Hemiptera*, eight parasties besides other miscellaneous insects, as ants, earwigs and rove beetles.

The problems of insect life are so interesting and so varied in Hawaii that the repetition of the investigation referred to above would well repay any observer on Oahu, while the insect fauna varies to such an extent on the different islands that the work, if repeated on Hawaii or Kauai, for example, would have all the novelty of original research.

Some of the more minute and scarcer groups of Hawaiian insects have not as yet been systematically studied. The larger and more important orders that have been reviewed by specialists are constantly having new genera and species added to them as a result of more detailed study. This makes generalizations based on the data available less accurate than one could wish. Nevertheless, some of the main facts selected for a popular resumé of the orders as discussed in the Fauna Hawaiiensis, supplemented by the papers on various phases of the subject that have appeared from time to time since their publication, may be of general interest.

Ants, Bees and Wasps.

The great order,[2] including the ants, bees, wasps, small four-winged parasites, and gall-forming and plant-eating wasp-like insects, is well represented in Hawaii. The order is divided into two sub-orders, one the boring,[3] the other the stinging[4] *Hymenoptera*. In the former sub-order, among other characteristics, the tip of the abdomen in the females is provided with an organ suited to boring the hole into which the egg is deposited. In some species this instrument is used to drill holes in trees, in others it is used to thrust the egg into the body of some other insect where it develops. Many of the species are very minute; often their existence is accidentally discovered during the process of rearing other insects in breeding jars. At such times the tiny parasite often emerges from the body of its host and appears in the jars as a microscopic insect with four wings. These are known as parasitic *Hymenoptera*, and are of great biologic importance in keeping their host species in

[2] *Hymenoptera*. [3] *Terebrantia*. [4] *Aculeata*.

check. Dr. W. H. Ashmead, in his treatise on the Hawaiian forms, discusses fourteen families belonging to this suborder, to which he refers one hundred and twenty-eight species as belonging to sixty-nine genera. Eighty-seven of the species were described by him as new. To this number several species have since been added, but as the very largest Hawaiian species do not exceed twenty millimeters, and by far the greater number are less than five millimeters in length, and as a great many have been described from a single specimen, we may infer that, in spite of their interesting habits, they are too small to attract much attention from the layman.

The stinging *Hymenoptera* includes about two hundred well-marked species. Of these a large number are peculiar to the islands. As the majority of the species are fair-sized, handsome insects, they have been more extensively collected. The group includes the ants, digger-wasps, the true wasps and the bees. To the twenty species of ants [5] listed by Prof. A. Forel as occurring in Hawaii, six species have since been added, the majority of which are new arrivals. As a matter of fact, there appears to be but one or two endemic species of ants in the islands. Most of those found here are slightly-varied forms of widely-distributed species. Only one species *(Ponera perkinsi)* is definitely stated to be Hawaiian. It occurs in small colonies of a dozen or so in moist localities high in the mountains.

Ants occur commonly in great numbers about houses, and everywhere attract attention owing to their so-called instinctive powers. They invariably live in organized communities or colonies, and exhibit as great a variety of habits and customs as do the people living in the islands, for the people, like the ants, have been brought together in Hawaii from many foreign lands. The ants found here live under boards and stones, and in the ground, and are as industrious and thrifty as those King Solomon observed, to find that they, having no guide, overseer or ruler, provided meat in the summer and gathered food in the harvest.

The home life of ants for obvious reasons has not been as fully studied as has that of the bees, but the division of labor in the colony is known to be even more complex. Their habits furnish an interesting and ever-present field for study and observation by old and young.

The digger-wasps, or Fossores,[6] may be readily distinguished from the true wasps by the fact that their wings, when at rest, lie flat over the back and the legs are arranged for walking or digging. There are about thirty-five species so far reported from Hawaii, the most common being the introduced mud-dauber [7] belonging to the thread-waisted wasp [8] family. They are to be seen building their nests about lanais and outbuildings. When the nest is completed the eggs are deposited and the cell provisioned with spiders. The truly native species are reported to prey entirely upon flies. The principal genus, *Crabro*, represented by fifteen species, is distributed in the mountains of the larger islands.

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[5] *Formicidæ.* [6] *Sphecina.* [7] *Pelopæus cæmentarius.* [8] *Sphegidæ.*

Of the true wasps,[9] the family [10] including the social wasps is represented by two or three species, one of which [11] is widely distributed about the islands.

The family embracing the solitary wasps [12] is represented by a large number of species belonging to the genus *Odynerus*. Eighty-six species were reported in the Fauna Hawaiiensis, and a dozen or more species have been added since. Excellent keys to the species occurring on the different islands have been prepared by Dr. Perkins, who reports sixty species from Oahu, eighty-four from Maui, Molokai and Lanai, and thirty-two from Kauai. Fourteen species have been found on Tantalus, including some of the rarest, while Kilauea as a locality has yielded twenty-one species. On a single day's collecting in Iao Valley, Prof. Swezey secured eleven out of sixteen species known to occur in that particular locality, which is about half of those so far reported from the Island of Maui.

In this genus the abdomen is joined to the thorax by a very short peduncle. The shape of the body and the coloration of the abdomen of many species so closely resemble those of the social wasps, known elsewhere as yellow-jackets, and hornets, that it is quite common to hear these names applied to the conspicuously-marked species. But as a rule, the Hawaiian *Odyperus* are much more somber in color than are species from elsewhere.

The habits of the Hawaiian species, like those of the genus occurring in other lands, varies greatly. Some species burrow into the stems and pithy parts of plants, others into dead wood, while a few build single cells of mud, which they attach to leaves of trees. Many of the species build their nests in the porous cavities in the lava rock; others make their nests in the ground.

The black rock-wasp,[13] one of several species common about vertical ledges of rock, attaches its egg by a slender thread at the back of some small hole in the rock. It then fills the hole with caterpillars that have been paralyzed by its sting. In storing the food for its young it is usually particular to select only the young caterpillar of a single species. Many of these, as we shall see, are leaf-rollers in that they protect themselves from their enemies and the sun in the caterpillar stage by folding the leaf together about them. The wasp, after locating the young caterpillar in its hiding-place, alights on the leaf nearby. The young caterpillar then becomes excited and creeps out of its hiding-place and falls to the ground, whereupon the waiting wasp will pick it up, sting it, and carry it away to its storehouse cell. When the cell cavity is full, the ingenious insect plugs up the end of the hole with mud, through which in due time the young wasp will emerge. The habit of storing their cells with the larvæ of moths and butterflies is very common among the solitary wasps, and as they are active during the year they do much to keep these insects in check.

The keyhole wasp [14] is a black wasp with dull-blue iridescent wings clouded with brown, that is common about houses, where it employs at least a part of its time in plugging up keyholes. They are interesting and intelli-

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[9] *Diploptera*. [10] *Vespidæ*. [11] *Polistes aurifer*. [12] *Eumenidæ*. [13] *Odynerus* spp.
[14] *Odynerus nigripennis*.

gent creatures, and are excellent material for the student who has the time and a taste for experimenting with animals. For example, they are greatly disturbed by a change in the color of objects near where they are working. If a piece of red cloth is tied over the door knob they have great trouble in finding the keyhole when they return with mud, but if the cloth is removed in their absence they have no trouble in locating it.

The Hawaiian solitary bees, of which there are at least sixty species, belonging to the genus *Nesoprosopis*, are not readily identified by the layman, nor are they easily separated in the field from the wasps. Like the genus of wasps just discussed, they vary greatly in habits. Some nest in the ground, some in dead standing timber and various unusual places, and are distributed from the coast to above the upper forest.

Of the typical or long-tongued bees,[15] we find five species so far occurring in Hawaii. Of these the conspicuous carpenter bee[16] and the useful honey bee[17] have already been mentioned. The three remaining species belong to a single genus[18] and are characterized as leaf-cutting bees. The common name is given them owing to their curious habit of making the thimble-shaped nests for their young out of neatly-cut circular pieces of fresh leaves, which they pack away in cells, often in holes in the woodwork, or in curled-up leaves of the cocoanut palm. Leaves when mutilated by these bees look as though small gun wads had been cut from them. The work of the wad-cutting bee is often mistaken for that of the Japanese beetle, which, while it feeds on the leaves, does not cut out the leaf in a regular pattern.

The Beetles.

Coming to the great order of beetles,[19] we find it represented in the Hawaiian insect fauna by more than forty families, embracing hundreds of precinctive and introduced species. All of the members of this extensive order are easily recognized in the adult stage, as they have a pair of horny wings that meet in a straight line down the back, beneath which is a single pair of membraneous wings neatly folded away. The earwig[20] is the only other order occurring in Hawaii that at all closely resembles them, and the earwigs are easily recognized by the presence of a pair of forceps-like appendages at the posterior end of the body.

In general it may be said that a great per cent of the beetles found in Hawaii are species that occur in no other place. Most of the species are small, many of them being almost microscopic in size, and as a rule the indivaduals of a species are not numerous, hence they are difficult to obtain. The collector soon learns that their habits vary greatly in the different families and even among the species of the same genera, so that in searching for specimens every possible situation must be examined. The water, earth, sand, crevices in the solid rock, under decaying animal and vegetable matter, under stones, in the

[15] *Apidæ*. [16] *Xylocopa brasilianorum*. [17] *Apis mellifica*. [18] *Megachile*. [19] *Coleoptera*. [20] *Euplexoptera*.

wood, stems and bark of trees, on the leaves, flowers, and in the seeds of plants, in moss, in fungi, in fern stems—in fact, a thousand possible places are all liable to be inhabited by some rare and interesting beetle.

That many species, especially among the long list of those introduced since commerce was established with Hawaii, are injurious to man and to his interests, has been touched upon in a former chapter. That many forms work to man's economic benefit has also been hinted at. Of most of the peculiar native species little is really known of the place they occupy in the economy of nature.

The larvæ, commonly called grubs, seldom display conspicuous characteristics, and exhibit nothing to indicate the diversity of form assumed by the adults. They are mostly dingy-white, brownish or occasionally even black in color. The head is always horny and usually provided with jaws suited to biting and grinding their food. The pupa stage follows the larva and varies greatly in length of time. Whether it is passed in a cocoon or not, the embryo beetle lies inactive with the appendages all plainly shown, each enveloped in its own peculiar covering. From this they emerge in due time to take up the active life of the adult.

Passing to a consideration of a few of the more interesting or more important families, we find that of the great division known as the predaceous beetles, the ground beetles,[21] with legs suited to running and with thread-like, tapering antennæ, are represented by more than two hundred small species, many of them belonging to genera peculiar to the islands. They vary greatly as to habits, the most of them, however, undoubtedly feeding on insects. They are found under stones, beneath dead wood, in moss, in trees, under bark, at the base of leaves and on the ground, scurrying about. Two small species of predaceous diving-beetles [22] belonging to this division, but to different genera, occur in fresh water all over the group; they appear to be nowhere abundant.

The diving-beetles can be distinguished at once from the six species of water scavenger-beetles,[23] some of which occur in pools and running water, and some in rotten wood and decaying vegetation. The water scavenger-beetles all have club-shaped antennæ (which are often concealed beneath the head) and very long palpi. As a matter of fact, these aquatic scavenger-beetles belong to the extensive division of the beetle order known as clavicorn beetles, in which the antennæ are club-shaped—that is, they grow gradually thicker towards the top. Hawaii has twenty or more families belonging to this group, including such well-known families as the carrion-beetles,[24] with but a single introduced species so far found; and the rove-beetles,[25] with upwards of one hundred species. They may all be fairly well recognized by their short wings and long, narrow abdomen. They are mostly carnivorous, and rove about in search of food. Insects constitute a large part of their food, especially insect larvæ, but many feed on rotton wood, some on fungi and others on flowers.

The twenty species of small hemispherical lady-bugs, or ladybird beetles,[26]

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[21] *Carabidæ.* [22] *Dytiscidæ.* [23] *Hydrophilidæ.* [24] *Silphidæ.* [25] *Staphylinidæ.* [26] *Coccinellidæ.*

discussed elsewhere, are practically all introduced species, brought to Hawaii on account of their well-known predaceous habits. The dermestes,[27] the common forms introduced and which destroy household stores and goods, have also native species of small size. The histerid beetles[28] have several introduced species and an important Hawaiian genus with thirty or forty species of very small square-shaped beetles that occur about decaying matter in the mountains. The nitidulids,[29] a family composed of small flattened beetles with the wing covers more or less truncate, exposing the abdomen, suggesting the rove-beetles which have a much longer abdomen, are quite common; one hundred and forty species, all of which feed on decaying animal and vegetable matter, and are often found about flowers, occur in the mountains.

Several other families made up of small-sized individuals and a limited number of species, belong in this division, and may occasionally be captured by the careful collector.

The group known as the serricorn beetles, since the antennæ are usually saw-like, is well represented by three families, the most extensive and common being the click-beetles,[30] snapping-bugs or skip-jack beetles. If disturbed they curl up their legs and apparently drop dead, usually landing on the ground on their backs. With a sudden click, they will spring up in the air and turn over. If they strike the ground on their feet they will run; if not, the clicking performance is repeated again and again. The adults are usually dull-colored, but some are of fair size and quite common. The larvæ are commonly known as wire-worms. Eighty-five species or more belong to the genus *Eopenthes*, a genus that includes some beautiful irridescent species that numbers among them some of the most attractive beetles in the islands. The checkered beetles,[31] with three widely-distributed species, and the metallic wood-borers,[32] including two introduced species, conclude this part of the order.

Beetles with the antennæ arranged so that the outer joints are prolonged internally in a manner to present flattened surfaces to each other, are grouped under the lamellicorn beetles, and are represented in Hawaii by such well-known families as the stag-beetles[33] or pinch bugs, so called on account of their large mandibles. The rare genus *Apterocyclus*, including the seven species of the family occurring in Hawaii, is found only on the Island of Kauai.

All of the eight or more species of Scarabæids[34] belonging to the foregoing section, and including such widely-distributed forms as the Japanese beetle,[35] have been introduced. Other members of this extensive family, including such classic forms as the May beetle, tumble-bugs, dung-beetles, skin beetles and the like, may accidentally gain admittance here from time to time, as two dozen species of beetles were prevented from landing in 1912 only through the rigorous insect inspection in force in Hawaii.

The group[36] including the long-horned beetles[37] is well represented by

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[27] *Dermestidæ*. [28] *Histeridæ*. [29] *Nitidulidæ*. [30] *Elateridæ*. [31] *Cleridæ*. [32] *Buprestidæ*.
[33] *Lucanidæ*. [34] *Scarabæidæ*. [35] *Adoretus tenuimaculatus*. [36] *Phytophaga*. [37] *Cerambycidæ*.

more than sixty species of that family alone. The list of species includes some of the most highly-colored as well as striking forms of Hawaiian beetles. As these are all wood-boring beetles in their larval state, many of the species most commonly seen have been introduced, but in the group including the three genera *Clytarlus*, *Callithmysus* and *Plagithmysus* we have several species that are peculiar to single islands and some that apparently occur only on certain kinds of trees. Such habits indicate the long establishment of the family in the group.

The division of the beetle tribe embracing the darkling-beetles,[38] which includes among other common species the red-rust flour beetle;[39] the oedemerids,[40] with one species, and the anthicids,[41] with two coast and salt marsh species, is made up of representatives of introduced families, except in the case of the cistelid family,[42] a family including ten species belonging to two genera that are regarded by entomologists as certainly indigenous.

The family *Cioidæ* is of doubtful position, but is represented in Hawaii by forty-two species, twenty-nine of which belong to the genus *Cis*, the remaining fourteen to *Apterocis*. A few of the species are found on the large fungi common on koa trees, but the majority occur attached to dead limbs or under dead bark. As the very largest species does not exceed two and a half millimeters in length, they may easily escape detection.

The family *Anobiidæ*, with the introduced cigarette beetle[43] and the book-worm,[44] has upwards of 134 species occurring in Hawaii. One genus[45] has at least fifty species in the Hawaiian fauna. Another genus[46] has at least seventy Hawaiian species. Most of the species in the family are black or fuscous and none exceed five millimeters in length. The family *Lyctidæ* includes two, and the *Bostrychidæ* several, common introduced species. The bamboo beetle[47] belongs to the latter family and is rare; but a similar beetle[48] is fairly abundant.

The division of the *Colcoptera* known as snout-beetles[49] is one in which the head is prolonged into a beak. The largest and most important family of this division is the curculios,[50] or weevils, of which there are about one hundred and fifty species. The great majority of them are peculiar to the islands. The antennæ are placed at or beyond the middle of the snout, and are curiously elbowed, each terminating in a solid club. All parts of plants are subject to the attacks of the maggot-like larvæ, and in many instances, especially in the case of the introduced species, they do considerable damage. The snout-beetle,[51] found on rubber trees, sisal, etc.; the bean weevil,[52] rice weevil,[53] the sweet-potato weevil,[54] all are excellent examples of the family, but a native genus[55] has several larger but rare species, the largest being fourteen millimeters in length. The large genus *Oodemas* has upward of forty-five species, all of which are rare. The family *Anthribidæ* and the engraver

[38] *Tenebrionidæ.* [39] *Tribolium ferrugineum.* [40] *Oedemeridæ.* [41] *Anthicidæ.* [42] *Cistelidæ.*
[43] *Lasioderma sericorne.* [44] *Anobium paniceum.* [45] *Xyletobius.* [46] *Mirosternus.*
[47] *Dinodernus minutus.* [48] *Schistoceros cornutus.* [49] *Rhynchophora.* [50] *Curculionidæ.*
[51] *Pseudolus longulus.* [52] *Bruchus obtectus.* [53] *Calandra oryzæ.* [54] *Cylas formicarius.*
[55] *Rhyncogonus.*

beetles[56] are associated with the weevils. The latter family is represented by a limited number of rare species. These are small beetles that live under the bark of forest trees. It is said that with the engraver beetles the female lays her eggs in the side of the channel which she cuts in the wood under the bark, and that the larvæ when hatched cut channels at right angles to those of the mother, thus forming the curious engraver's pattern.

We come now to the remarkable Hawaiian snout-beetle family,[57] which, so far as known, is peculiar to the islands. The 136 species so far described are all referred to a single genus.[58] None of the species exceed four millimeters in length. They may be at once recognized as members of this family and differing from the weevils, owing to their long many-jointed antennæ, which are placed at the base of the beak and close to the eyes.

Most of the species are found about dead and dying forest trees, but some occur in fern stems, and one or two are found in the stems of the maiden-hair fern,[59] while one species was found by Prof. Swezey to be a leaf miner.

The Two-Winged Insects.

Passing over the order including the fleas,[60] as they have been mentioned in another connection, the next order embraces the two-winged insects[61] of which the house fly, the fruit-fly, the melon-fly, the lantana-fly and the mosquito may be taken as conspicuous introduced examples that play important roles on both sides of the balance sheet of insect economy in the islands. The life histories of any of the foregoing species may be easily and profitably worked out in the class-room.

The larvæ are usually footless, whitish creatures called maggots that revel in all sorts of filth, as stable manure, decaying fruit, in fresh and stagnant water, in the earth, about roots of plants and a variety of unsuspected places. The larvæ and the pupæ of the mosquito are known as wrigglers, and in this stage are a favorite food for certain species of fish introduced for the express purpose of preying on them.

The list of Hawaiian flies prepared by Mr. P. H. Grimsham in 1901-2 indicated 188 species as belonging to the fauna. Since then a number of species have been added, so that, native and introduced, there are more than two hundred kinds of flies known to occur in the islands. Some of them are beneficial, others are troublesome, but the great majority of them are rare mountain forms seldom met with.

More than twenty-five families are represented by from one to several species, among them the fungus-gnats,[62] the moth-like flies,[63] the mosquitoes,[64] the window flies;[65] the long-legged flies,[66] of which there are a few interesting native species; the big-eyed flies,[67] parasites on leaf-hoppers; the syrphus flies,[68] the flesh flies,[69] the typical flies,[70] including the horn fly, blue-bottle fly, house fly, sheep-maggot fly and stable fly (the latter now believed by

[56] *Scolytidæ.* [57] *Proterhinidæ.* [58] *Proterhinus.* [59] *Pteris.* [60] *Siphonaptera.*
[61] *Diptera.* [62] *Mycetophilidæ.* [63] *Psychodidæ.* [64] *Cuculidæ.* [65] *Scenopinidæ.*
[66] *Dolichopodidæ.* [67] *Pipunculidæ.* [68] *Syrphidæ.* [69] *Sarcophagidæ.* [70] *Muscidæ.*

certain investigators to be the carrier of infantile paralysis); the horse and ox bot-flies,[71] the fruit and vegetable flies;[72] but by far the most numerous in point of peculiar species are the small vinegar flies or pomace flies.[73] Of these there are at least forty-five species peculiar to the islands. They are attracted to decaying fruit and vegetable matter in great numbers, especially to pine-apples, where the species[74] is mistaken by many people for fruit-flies on that account.

The curious louse-flies,[75] which have very flat bodies and live like ticks on the bodies of birds[76] and occasionally on mammmals, are represented in the islands by species that are sure to arouse the curiosity of anyone observing them.

Butterflies and Moths.

The Hawaiian Islands possess very few butterflies, but have a very large number of moths. The moths and butterflies are all included in one order, *Lepidoptera,* owing to the fact that all of the members of this order are alike in having all four of the wings covered with minute scales. They all pass through complete metamorphosis; that is, the egg when hatched becomes a caterpillar, the caterpillar changes to a pupa, and the pupa, after a quiet period, turns into the adult winged insect. The mouth parts of the adult, when fully developed, are fitted for sucking nectar from flowers, but the mouth parts of the caterpillar are fitted for chewing, and it is in this stage that they do great damage to various kinds of plants. The amount of damage done in Hawaii is considerable, but a great part of it is done by introduced species, as has already been pointed out. However, the moths and butterflies have many natural enemies, and enemies have been introduced to aid in keeping them in check.

Without doubt the struggle for existence here had much to do with the production of forms that are protectively colored with reference to their enemies and their surroundings. When we realize that the order is represented in Hawaii by more than seven hundred species,[77] the great majority of which[78] are peculiar to the islands, we can realize the length of time and the amount of specialization involved in the production of this interesting portion of our fauna. With so large a list of species the collector is surprised to find so few individuals of a species and that the majority of those found are so minute.

For convenience the *Lepidoptera* have been divided into the *Macrolepidoptera* and the *Microlepidoptera.* To the *Macrolepidoptera* belong the few species of butterflies, (all with club-shaped antennæ), and the larger moths, making fifteen families[79] in all. Of this list but few are sufficiently marked

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[71] *Œstridæ.* [72] *Trypetidæ.* [73] *Drosophilidæ.* [74] *Drosophila ampelophila.* [75] *Hippoboscidæ.*
[76] As the pueo and iwa. [77] 733 according to Prof. Meyrick and Lord Walsingham in 1907.
[78] 661 species.
[79] According to Meyrick, the Hawaiian Macrolepidoptera belong to four super- families, and fifteen families, as follows: (a) Caradrinina—*Caradrinidæ, Plusiadæ;* (b) Notodontina—*Selidosemidæ, Sphingidæ, Hydriomenidæ;* (c) Papilionina—*Pieridæ, Nymphalidæ, Lycænidæ,* (d) *Pyralidina — Phycitidæ, Galleriidæ, Crambidæ, Pyraustidæ, Pyralididæ, Pterophoridæ* and *Orneodidæ.* These families are again divided into more than sixty genera.

as to habit or appearance to make their recognition at all easy or certain, even by the professional entomologist, without reference to cabinet specimens, schemes of classification and tables, based often on minute and obscure characteristics. Some of the species, however, warrant notice on account of their size or abundance, though the very largest island species of the order—a beautiful green sphynx moth [80]—does not exceed three and a half inches in expanse. It has four dull-colored cousins occurring on the different islands that are almost as rare. Like the foregoing species, the humming-bird moths are also members of the hawk-moth [81] family. Two species occur here. The one with the rosy, spotted abdomen,[82] known as the sweet potato horn-worm, is fairly abundant from September to December, while the species with the yellow-spotted abdomen is rarer, though both species are widely distributed in America. The commoner species has been mentioned among the economic insects.

Coming to the typical butterflies with knobbed antennæ,[83] we have the so-called four-footed butterflies,[84] represented by at least five species. Only one of them, however, the Kamehameha butterfly,[85] is native. Fortunately it is the most common species, especially in the lower forest zone. It can be recognized as differing from the three introduced species of the angel-wings, or vanesseds, by its larger size and having the body reddish-brown, while the body of a similar species [86] is black.

These bright butterflies with their wings of varied rusty brown, red, rose, black and white add a welcome touch of color to the forest green that is sure to delight every mountain rambler. The larvæ are conspicuous caterpillars found principally on the mamaki. They fold the margin of a leaf together to form a shelter, crawling out of it to feed. As they grow in size, they are known to form new retreats from time to time.

The monarch or milkweed butterfly [87] is represented by an introduced species, identified by its having the upper surface of the wings light tawny-brown, with the border and veins black, and two rows of white spots on the outer borders of all four wings. It is much the largest butterfly found in Hawaii. It is fairly common on the lower levels, where it feeds in the larval stage on the introduced milkweed.

The family of gossamer-winged butterflies [88] are represented by four species of the "blues," one of which, Blackburn's butterfly,[89] is peculiar to the group and is quite plentiful at proper seasons in the mountains on all the islands up to 4000 feet. All of the species are about an inch across the expanded wings. The native species can be identified at once by the light bluish-green, unspotted under-surface of the wings, and by the upper-surface being dark colored, edged with blue. One of the introduced species [90] is very abundant, its larvæ feeding on Crotalaria and other bean-like plants growing on the lower levels. The two remaining species of *Lycæna* have recently been pur-

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[80] *Deilephila smaragditis.* [81] *Sphingidæ.* [82] *Sphinx convolvuli.* [83] *Papilionia.* [84] *Nymphalidæ.*
[85] *Vanessa tammeamea.* [86] *Vanessa atlanta.* [87] *Anosia erippus.* [88] *Lycænidæ.*
[89] *Lycæna blackburni.* [90] *Lycæna bætica.*

posely introduced from Mexico to feed on the flowers and leaves of the Lantana.

The white cabbage butterfly[91] is the representative of the third family[92] of the butterflies occurring in Hawaii. Here, as in America, they are an introduced species, and, as elsewhere, they are common in gardens., especially about cabbage, where their larvæ, as cabbage-worms, bore into the cabbage heads and devour the leaves.

In the genus, to which the introduced black cut-worm[93] found feeding on garden and farm crops, sugar-cane and weeds belongs, there are enumerated at least two dozen native species. They are for the most part fair-sized, somber-colored, night-flying moths. Fortunately, the native species prefer to inhabit the higher forested areas, rather than the lower agricultural zone. However, there are several species belonging to the genus *Agrotis* as well as species of such genera as *Leucania, Heliothis, Spodoptera,* belonging to this extensive family[94] and to the related family[95] that furnish a number of forms that infest the grass and the crops of cultivated lands on the lower levels. One species,[96] with silver commas on the forewings, is an introduced troublesome general feeder that is liable to attack almost any useful plant.

The super-family *Notodontina,* with its three families and ten genera, furnish a number of species of considerable economic importance. One genus[97] in this division has perhaps thirty species that are among the more abundant and showy moths met with in the islands. Their caterpillars of different species often occur in large numbers on guava, koa, ferns and various other plants and trees.

Coming to the fourth super-family,[98] with seven families and thirty-two genera in the Hawaiian fauna, we find the various species of the genus *Omiodes* represented by the cocoanut palm leaf-roller,[99] among the most troublesome native moths. A genus[100] belonging to the same family[101] is represented by at least fifty-six native species of attractive moths that have the forewings very narrow and often conspicuously marked with spots, blotches and wavy designs of various colors. As the range of the genus seems to be between two and ten thousand feet in the mountains, species are usually secured from high, moist regions. They feed almost exclusively on moss and lichens, in which the larvæ are said to spin curious silken tunnels for themselves.

Up to the time Dr. Perkins began his work in the islands but thirty-five species belonging to the grand division of *Microlepidoptera* were known from Hawaii. Lord Walsingham, after working over the material assembled by Dr. Perkins, recorded four hundred and forty-one species. The labor involved in adding so many species of insect life to the fauna, by the efforts of a single naturalist, can be appreciated better when we realize that the great majority of these minute creatures do not exceed a half inch in length.

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[91] *Pieris rapæ.* [92] *Pieridæ.* [93] *Agrotis ypsilon.* [94] *Caradrinidæ.* [95] *Plusiadæ.*
[96] *Plusia chalcites.* [97] *Scotorythra.* [98] *Pyralidina.* [99] *Omiodes blackburni.* [100] *Scoparia.*
[101] *Pyraustidæ.*

On the wing these tiny moths fly with a rapid, confused flight and alight with the wings folded closely together over the body. As a rule they are protectively colored and secrete themselves in crevices in the bark, and beneath the dead leaves in the forest, with such skill as to defy detection even by the practiced eye.

While their habits vary greatly, many of the species develop to the adult stage within the tissue of leaves, and in this way come to be called leaf-miners.[102] Usually each species of the leaf-miner group infests some particular kind of plant or at least closely allied plants. So constant are these creatures in their leaf-mining habits that an expert entomologist can often tell the species of insect infesting the plant by the characteristic mine that it makes. Some species produce galls on certain plants, others feed on fruits, live in silken tunnels in dead grass and leaves, on the bark of dead trees; some produce webs in koa trees, and so on until it has been found that almost every imaginable habitat has been occupied by them.

Although the great majority of the species belonging to the *Microlepidoptera* are found in the mountains, there are many, both native and introduced, that may be seen about residences, in gardens or doing damage to field crops of various kinds. Perhaps the species most liable to attract the attention of ordinary observers are the morning-glory leaf-miners,[103] both of which are introduced in Hawaii. The destructive cotton boll-worm [104] is also an abundant introduced species that bores into the seeds of the cotton. The clothes moth;[105] the tobacco leaf-miner,[106] boring into potatoes and into fruits and stems of tomatoes, are two common species in Hawaii. The corn moth,[107] feeding in the kernels of corn stored in cribs, and in rice, is also a common pest. Thus the list might be indefinitely extended and made to include many species of more or less interest or importance. The species are so minute, however, and are so much like one another, that their determination is necessarily the work of a specialist. But from the standpoint of the native fauna, especial mention should be made of the large, variable Hawaiian genus *Hyposmocoma*, in which more than one hundred and seventy-five native species have been identified by Lord Walsingham. This list has since been extended by local entomologists. The larvæ make for themselves many styles of cases or cocoons which are located in such places as on the bark of trees, on rocks, dead twigs, or dead wood. A peculiarity of the genus is the variable form, size, color and construction of the cases which are made by the different species.

The Dragon-Flies and the Nerve-Winged Insects.

The dragon-fly may very properly be taken as a type of the order including the nerve-winged insects,[108] in which all four wings are membranous and furnished with numerous veins and usually with many cross-veins. Entomologists have differed among themselves as to just what the limits of the

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[102] *Tineidæ*. [103] *Bedellia somnulentella* and *B. minor*. [104] *Gelechia gossypiella*. [105] *Tinea pellionella*. [106] *Phthorimæa operculella*. [107] *Silotroga cerealella*. [108] *Neuroptera*.

order should be, but in the case of the Hawaiian fauna the order, as treated by Dr. Perkins, has been made to include insects familiarly known as lace-winged flies or hemerobians,[109] the dragon-fly,[110] the book-lice[111] and the white ants or termites.[112]

To this super-order have been referred at least 116 species of insects. About one-half of this number is made up by the lace-winged flies. They are slender-bodied, delicate insects of small size, the largest measuring scarcely more than an inch in length. They all have dainty membranous wings of various colors as gray, brown, yellowish-brown, hyaline, iridescent, and often pale green, the last color being the one most liable to attract attention.

The lace-winged flies are forest dwellers and nocturnal in habit. The common lace-winged fly[113] is quite frequently met with in gardens and shady localities, and may be easily captured.

Of the dragon-flies,[114] at least one genus,[115] with twenty-six endemic species, may be regarded as of very long standing in the islands. The members of this genus are all fond of the mountain forests and seldom occur at lower levels. They have very slender bodies, with both pairs of wings shaped nearly alike. So extraordinarily fragile, delicate and dainty are their wings that they are often called Hawaiian damsel flies. Their gentle and airy manner as they flit from leaf to leaf make them among the most attractive of the Hawaiian forest insects. There are from seven to ten species on each island, but at least two of them[116] occur throughout the group. As a matter of fact, the species of the genus are related to one another in such a way as to indicate that they all have originated from a single ancestral species that doubtless came to Hawaii in very remote times.

The nymphs of some if not all of the species belonging to this genus develop in the cups formed at the base of certain leaves in the forest, and can live with a very scant supply of water. Living specimens confined in collecting bottles continue active for several hours.

They are aquatic and predaceous in habit in every case, and are sure to attract attention with their rapid darting movements, their strong legs and jaws, and conspicuous eyes. The adults often flock to mountain pools during dry seasons, as they prefer moist localities. As a result, their dead bodies are often seen floating on the surface of the water.

Of the three other genera of *Odonata* found in Hawaii, the big blue dragon-fly[117] is the most conspicuous and abundant through the allied species; the strenuous dragon-fly[118] is common enough, but so strenuous indeed that it is difficult to capture specimens. The yellow dragon-fly[119] is the common species seen in the open country everywhere, but notably in the streets and gardens of Honolulu. At the proper season as many as twenty may be seen at one time hovering over a square rod of lawn.

Another species of pinau,[120] as all dragon-flies are called by the Hawaiians,

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[109] *Hemerobiidæ*. [110] *Odonata*. [111] *Psocidæ*. [112] *Termitidæ*. [113] *Chrysopa microphya*.
[114] *Odonata*. [115] *Agrion*. [116] *Agrion xanthomelas* and *A. pacificum*. [117] *Anax junius*.
[118] *Anax strenuus*. [119] *Pantala flavescens*. [120] *Tramea lacerata*.

are common in the open country on the lowlands. Still another species[121] is found in the forest and deep valleys and has doubtless long been a resident of the islands.

The three genera[122] above mentioned are strong fliers and liable to have been natural immigrants at a less remote time. The nymphs feed voraciously on the larvæ of mosquitoes, and are of value in the struggle to keep them under control.

The small common white ant,[123] found about buildings, was doubtless introduced. This species and the peculiar Hawaiian species[124] found in the native forests are, so far, the only representatives of the white ant family[125] in the islands. But as indicated in a previous chapter, they do much damage.

Quite recently two species belonging to the ant-lion family[126] have been found in the islands. One of the species[127] occurs on Oahu; the other, and by far the more common, on Hawaii.

The remaining families[128] are so small as to hardly attract attention at all, though the Psocids, or "book-lice," are represented by twenty-five or more species, and the list of species could easily be extended by further systematic study.

The True Bugs.

The order *Hemiptera* includes many well-known insects with mouth parts fitted for sucking the juices from fresh vegetation and blood from animals. They are well represented by the true bugs, plant-lice, scale insects, aphids and a number of allied families.

Mr. G. W. Kirkaldy, who devoted much time to the portion of the Hawaiian fauna belonging to this order, estimated that there were at least five hundred endemic, migrant and introduced species in the islands, of which number about three hundred and sixty were peculiar to the group.

As a rule they are represented by small and, in many cases, by rare and inconspicuous species, but as many are well-known pests, the families of great economic importance have been studied by entomologists. As the more important economic species in the various families have been dealt with in another connection, it only remains to mention a few representative examples distributed among the eighteen families recorded from the group, and to note that but twelve of these families have species belonging to the endemic or native fauna.

In the sub-order, including the true bugs,[129] the first pair of wings are thickened at the base, ending with thinner extremities that overlap on the back. In this division are found insects that live on the land, in the water, and on the surface of the water in marshy places.

Of the land species, two representatives of the chinch-bug family[130] are

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[121] *Sympetrum blackburni.* [122] *Anax, Tramea* and *Pantala.* [123] *Calotermes marginipennis.*
[124] *Calotermes castaneus.* [125] *Termitidæ.* [126] *Myrmeleonidæ.* [127] *Formicaleo perjurus.*
[128] *Psocidæ* and *Embiidæ.* [129] *Heteroptera.* [130] *Lygæidæ.*

of recent introduction. The red-bug family [131] has a single introduced species; the family *Myodochidæ* has a number of species, among them the several members of the Hawaiian genus *Nysius*—insects less than six milimeters in length. The curious Lantana bug,[132] purposely introduced, is the only representative of its family [133] in the islands. The damsel-bugs,[134] so called for want of a better name, are well represented by several Hawaiian species belonging to a large genus.[135] The assassin bugs [136] have won their popular name on account of their predaceous habits. A dozen species, most of them of fair size, and usually of wide distribution, occur in the islands. The large assassin bug,[137] or kissing bug, is thirteen millimeters in length, and is doubtless an American species that first appeared in Hawaii about 1897. The minute, slender-bodied *Miridæ* are represented by several species of small insects, belonging to a number of genera, none of which are liable to be seen by casual observers.

Conspicuous among the few species of insects that live on or within the water in Hawaii is the representative of the family of water-boatmen.[138] It is represented by a small oval, gray and black mottled species [139] that has the body flattened above and swims on the ventral surface. This peculiar habit is of value to the novice in identifying them, since in this they differ from the next family, in which the various species all swim on their backs.

When the water-boatmen swim through the water they are almost completely enveloped in air which gives them a silvery appearance. If they stop swimming or lose their hold on the bottom they quickly come to the surface, as their bodies enveloped in air are much lighter than the water. They occasionally float on the surface of the water, or slowly paddle about with their oar-shaped legs. When they choose they can leap from the water into the air and fly away. They feed principally on other insects and lay their eggs upon water plants.

The back-swimmers,[141] like the foregoing family, are represented by a single species [141] that happens to be one of wide distribution. The favorite attitude of the back-swimmers is floating on the surface of the water back down, with their long oar-like legs stretched outward and forward ready for making a stroke. When disturbed they will dart out of the way, usually by going rapidly to the bottom, there to remain hidden for some time. Other minute bugs,[142] with minutely-spotted wings in the adult and with a red edge to the abdomen in the immature stage, that walk about on the water, especially in stagnant, weedy pools, are very common. They belong to a totally different family [143] of insects from either of the two species just described, and in turn may be easily confused with rarer species of bugs and flies that frequent similar places.

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[131] *Pyrrhocoridæ.* [132] *Teleonmia lantanæ.* [133] *Tinguidæ.* [134] *Nabidæ.* [135] *Reduviolus.*
[136] *Reduviidæ.* [137] *Zelus renardii.* [138] *Corixidæ.* [139] *Arctocorisa blackburni.* [140] *Notonectidæ.*
[141] *Buenoa pallipes.* [142] *Microvelia vagans.* [143] *Gerridæ.*

Plant-Lice.

The sub-order[144] to which the plant-lice, the jumping plant-lice, the lantern-flies and similar insects belong, is made to include a number of odd bugs with suctorial mouth parts. Though they differ widely in form, they usually agree in that when the wings are present they are of the same thickness throughout. When at rest their wings are held slanting, roof-like, at the sides of the body.

Leaf-Hoppers.

The tree-hoppers[145] if represented in the fauna are included only as recent introductions; one species[146] was taken as long ago as 1908. The leaf-hoppers,[147] better known as jassids, are slender, minute, inconspicuously-colored insects which, like the lantern-fly family[148] and closely-allied families, are represented in the Hawaiian fauna by a very few species. The sugar-cane leaf-hopper[149] is by far the most destructive member of a family[150] to which have been referred ten genera, including thirty species of Hawaiian insects. They are arboreal in habit, favoring the higher elevations. They average about four millimeters in length and are extremely difficult to identify specifically.

In a synopsis of the family of Aphids or plant-lice,[151] Prof. D. T. Fullaway enumerates twenty-one species belonging to eight genera as occurring in the Hawaiian fauna. A large number of these are of economic importance, and have had notice in a chapter devoted to that phase of the local insect life.

The *Aleyrodidæ*, which formerly were included with the scale-bugs and mealy-bugs,[152] are represented by six known species, while the coccids have close to one hundred species in the fauna, almost all of which have been brought to Hawaii within the last one hundred years. Of this number only two are thought by specialists to belong to the native insect fauna.

Thrips.

The thrips[153] are microscopic insects so small that they rarely attract the attention of even observant persons. Under a hand lens or the microscope the adults show their four long narrow wings, of nearly equal size, to be fringed with long hairs. These are laid horizontally on the back when at rest. However, in many of the Hawaiian species the wings have been reduced to functionless pads. Thrips are to be found in various places, as in flowers, lichens and moss, and on the underside of stems, leaves and stalks of grass, plants and shrubs. Their mouth parts show them to be intermediate between the sucking and biting insects, and, as one would expect, they are known to feed on other insects and upon vegetation. Four families are represented by twenty or more species, the most of which are black, brown or chestnut-brown in color.

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[144] *Homoptera.* [145] *Membracidæ.* [146] *Centrolypus* sp. [147] *Tettigoniidæ.* [148] *Fulgoridæ.*
[149] *Perkinsiella saccharicida.* [150] *Aviracidæ.* [151] *Aphidæ.* [152] *Coccidæ.* [153] *Thysanoptera.*

One species[154] found here in the mountains is common in greenhouses in Europe and America. The mango thrip,[155] occurring in Hawaii, is a species belonging to the same genus. Other species occur on cultivated plants.

Grasshoppers, Crickets, Cockroaches and Earwigs.

The order *Orthoptera*, as treated in the Fauna Hawaiiensis, is made to include such well-known insects as the grasshoppers, crickets, cockroaches, earwigs, and other forms with conspicuous mouth parts formed for biting, and with the lower lip divided in the middle. The mode of growth in each individual is by increase in size without any abrupt change in form except that the wings, when present, are only developed in the final condition of growth. In several forms the wings are rudimentary and not suited for flight.

The *Orthoptera* are all insects of comparatively large size, and many of them, on account of their voracious appetites, are very destructive to cultivated plant life.

The earwigs[156] are elongated, dark-colored insects bearing at the posterior end of the body a pair of curious pincer-shaped organs. They are common insects in Hawaii, occurring commonly in gardens and cultivated ground, as well as far up in the mountains. They are fond of concealing themselves in places difficult to enter. The name "earwig" is said to be due to a belief that the creatures are fond of creeping into the ears of persons while asleep. This curious and apparently groundless superstition is current in Hawaii, as well as in almost every other country these creatures inhabit. They are mainly carnivorous in habit and generally regarded as beneficial insects.

Ten species belonging to four or five genera are reported as occurring in the islands. Most of the species are of undoubted recent introduction, some of them very recent, while one which inhabits the mountain forests of Kauai,[157] and a rarer species[158] from Oahu, may have developed from early natural immigrants.

The cockroaches,[159] with at least sixteen species belonging to thirteen genera, are well known in Hawaii, where certain species are abundant household pests. They are all easily recognized by the common characteristics of the order that are well exhibited by familiar species. They all feed at night and fly from the light with a rapid scurrying gait which is peculiar to them. Only one species[160] is believed to be truly endemic. It is found only in the mountains among the leaves of native plants. The other species frequent the inhabited areas to such an extent as to preclude the possibility of their belonging to the native fauna, even though, as in one or two instances, they have never as yet been taken outside of the islands.

The two larger common house roaches,[161] of which the American species is the larger, have already been mentioned; but six or seven species are liable to occur about buildings, often in company with them.

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[154] *Heliothrips hæmorrhoidalis*. [155] *Heliothrips rubrocinctus*. [156] *Dermaptera*. [157] *Anisolabis pacifica*.
[158] *Anisolabis littorea*. [159] *Blattodea*. [160] *Phyllodromia obtusata*.
[161] *Periplaneta americana* and *P. australasiæ*.

Two species of praying mantes,[162] or mule-killers, belonging to two different genera, have been introduced. One, the Australian mantis,[163] occurs on Kauai; the other, known as the Chinese praying-mantis,[164] on Hawaii, where it was first taken in 1900. These curious-looking insects, with pious faces and front legs clasped meekly together, are not so pious as they appear. They are insect feeders with a desire for food that is seldom satisfied. They are harmless to man and beast, though the curious form of their body gives them a formidable and menacing appearance.

The short-horned grasshoppers[165] or locusts are now represented by two or three introduced species. In these the antennæ are shorter than the body, and the ovipositer of the female is made up of four short separate parts.

The green species with the long, sloping head, suggesting a dunce-cap, which is known as the Australian grasshopper,[166] was accidentally introduced from that country about 1887 and has since become common on Oahu and Kauai, and perhaps other islands. A more typical species with a square head[167] was introduced probably from Australia also, and has since become quite common about Honolulu.

The long-horned green hoppers[168] always attract attention by reason of the extreme delicacy and great length of their antennæ, which always exceeds the body in length.

The common meadow grasshopper[169] is well established all over the islands in open pasture land and on mountainsides, and serves as a common type of a group of insects represented by at least thirteen species and four genera. Two of the genera—the one mentioned above and one with a single species,[170] also common on the plains, about rice fields, and the lower mountains—are introduced. The other two genera, one with ten species[171] and one with a single species,[172] are endemic. As the single large, green native species, belonging to the last genus, has only been secured from Olaa, any rare green or brown grasshoppers, with long antennæ, taken elsewhere in the mountains of the group can with safety be referred to the larger genus by the novice.

The crickets[173] all differ from both the long-horned and the short-horned grasshoppers in having the wing covers flat above and bent sharply down at the edge of the body, suggesting the lid of a box, instead of meeting in a ridge above the body like a roof. As a rule, the males have a very different appearance from the females—a difference so marked that in one instance the sexes were placed in separate genera. There are in Hawaii about forty species of crickets belonging to ten genera. Of that number, three dozen or more are recognized as peculiar to Hawaii, and for the most part confine their range to the native forests on the different islands. Sixteen of the native species are placed in a single genus with a brown mountain cricket[174] as the most widely-distributed, abundant and easily-captured species. They are fond of the wet

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[162] *Mantoidea.* [163] *Orthodera prasina.* [164] *Tenodera sinensis.* [165] *Acridiodea.*
[166] *Atractomorpha crenaticeps.* [167] *Oxya velox.* [168] *Locustoidea.* [169] *Xiphidium varipenne.*
[170] *Flimæa appendiculata.* [171] *Brachymetopa.* [172] *Conocephaloides hawaiiensis.* [173] *Gryllodea.*
[174] *Paratrigonidium pacificum.*

woods and damp gulches, and are usually found on the ground. They sing all day long and most of the night, with a plaintive chirp that is an audible sign of the moist virgin forest. Their chirp can usually be heard a long way, and as they occur in localities frequented by tree snails, their song is often spoken of by the layman as the chirp of these tree-dwelling animals.

The leap of these insects is worthy of remark, as during the first leaps they can cover several feet in a single bound. But after a few jumps they lose their strength and make for cover on a run. The habits and appearance of the remaining species of the genus, and of the remaining mountain genera varies greatly, some being arboreal, some hiding beneath the bark of trees, and some frequenting peculiar species of trees or plants.

The introduced species, including the curious mole-cricket,[175] elsewhere referred to, and two species of the true crickets, one of which [176] is common and well established, the other [177] a more recent introduction, occur about houses and gardens, especially in Honolulu. The familiar chirp of the true crickets adds a homely note to the music of the soft tropical evening in Hawaii, and all agree that their song more than repays the slight damage they may do to vegetation and to stored food.

Wingless Bird-Lice.

The wingless bird-lice [178] are minute parasitic insects with biting mouth parts that live among the feathers of birds. They are to be found on both the native and introduced birds of Hawaii. The list includes upwards of twenty species taken from a dozen species of the common birds and doubtless falls far short of a complete enumeration of the bird-lice to be found in the group, since, of the twenty species recorded, seventeen are described as new to science. While the rule is for each species of birds to have its own peculiar form, it is not unusual to find several species of bird-lice infesting a single bird. The beautiful red iiwi,[179] for example, is infested with three genera representing three species, and the Chinese dove with two.

Silverfish and Spring-Tails.

The spring-tails [180] are included in an order of insects that are entirely without wings in all stages of growth. Five species so far reported from Hawaii are minute silvery, yellowish or pale-colored creatures usually less than two millimeters in length. They are provided with a curious tail-like organ which is bent under, when the insect is at rest, that reaches almost to the head. This organ, when suddenly straightened, throws the insect into the air like a rocket to land several feet away, presumably in a place of safety. The species so far secured have been taken from the high mountains under bark and from other sheltered places, but their general habits are unknown.

Coming to the most primitive order of living insects,[181] familiarly known as bristle-tails, fish-moths or silverfish, we find the order represented by

[175] *Gryllotalpa africana.* [176] *Gryllus innotabilis.* [177] *Gryllus* sp. [178] *Mallophaga.* [179] *Vestiaria coccinea.*
[180] *Collembola.* [181] *Thysanura.*

several species peculiar to the islands. At least one or two among them, especially the common silverfish,[182] were introduced. They are all active insects that live in obscure places and, like the spring-tails, they never exhibit any trace of wings. The silverfish has a distinctly segmented body, covered with minute hairs or scales, which terminate in two or three bristle-like appendages. The four native species so far reported belong to two families and have all been described from specimens collected in the native forest. The native species from Oahu[183] occurs also on both Maui and Kauai, and is about thirteen millimeters in length. Doubtless there are other species to be discovered, as the mountains of the islands mentioned are the only localities from which these interesting insects have as yet been reported.

CHAPTER XXXIII.

LAND AND FRESH WATER SHELLS.

The land shells of the Hawaiian Islands have been more extensively collected and minutely studied than any other group of animals in the islands, and it is doubtful if any single group of animals in the world has contributed more really striking material for systematic study or received more attention from students of evolution.

Land Shells.

The first Hawaiian land shells to be examined by Europeans were specimens secured by Captain Dixon from a shell lei or necklace which was procured in the islands on the occasion of his memorable visit. He carried the specimens back to England and described the first species as *Turbo apex-fulva* in the report of his voyage round the world, which was published in 1789. From that time to the present land shells from Hawaii have been eagerly collected by almost every one with a taste for general natural history.

Almost every boy in Hawaii has at one time or another made his collection of land shells, and a long list of scientific men and energetic collectors, past and present, have given much time and thought to the collection and study of this most interesting group of mollusks.

While there are perhaps fifteen well-established families with as many as thirty-five genera represented in the entire land and fresh-water shell fauna of the islands, it is the beautifully and conspicuously-colored tree-dwelling forms, commonly known as "tree snails," that are most generally sought for by the shell enthusiasts. Moreover, they are the forms upon which most of the important systematic and philosophic work of the past has been based. According to Mr. E. R. Sykes, who published an extensive paper on the subject of the Hawaiian Mollusca as late as 1900, at least three hundred and twenty-two of

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[182] *Lepisma saccharina.* [183] *Machilis heteropus.* [1] *Achatinellidæ* (see page 433).

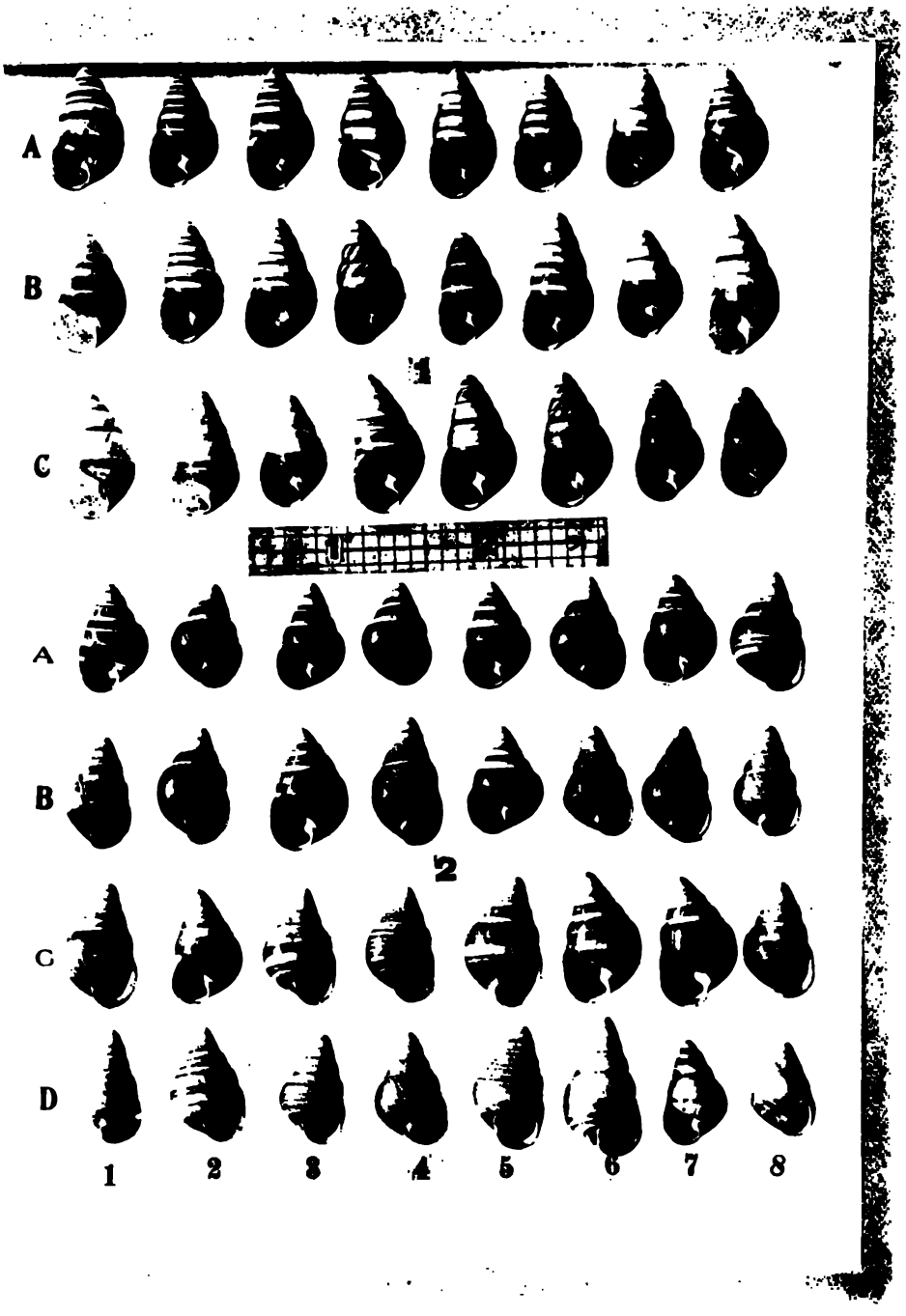

PLATE 100. COLOR VARIETIES EXHIBITED BY TWO COMMON SPECIES OF LAND SHELLS.

1. *Achatenallastrum varia* and varieties. 2. *Apex mustelina* and varieties.

the approximate five hundred species and varieties of Hawaiian land and fresh-water shells then known, were placed in the one family [1] which, according to his view, was made up of nine genera. Of that number the four genera, *Achatinella, Amastra, Leptachatina* and *Auriculella,* contain the great bulk of the species. These names occur so often in the literature on the shells of the group, and are represented by such extensive and handsome series in the various noteworthy collections in the islands, that the remaining genera of the family and the long list of genera belonging to other Hawaiian families too often appear to be lost sight of.

Variations.

The super-genus *Achatinella,* for example, is represented by upwards of one hundred species,[2] the majority of which grade through such a perplexing variety of shades and forms that it is usually impossible to fix the exact limits of the species. Indeed, Rev. E. W. Thwing collected from various sources and published no fewer than three hundred and fifty-eight descriptions that have been applied by different authors to the various forms in the above genus alone.

With so long a list of names founded on such variable characteristics as size, shape, locality, color pattern, banding and other variable markings to be considered for the most part as synonyms, the amateur collector although he may be provided with the literature on the subject—a literature which includes more than two hundred titles—finds himself involved in an almost endless confusion of names. What is worse there is such a diversity of opinion among the authorities on the minute points involved in the classification of the shells in this important genus, that for the present, at least, the student in desperation is reduced, as a rule, to simply keeping his shells, gathered from various localites carefully separated—usually labeling them by valleys, ridges, side ridges, spurs and in some cases indicating the particular bush or tree from which they were taken, in the hope that some day the subject of nomenclature will be definitely settled.

Nevertheless, this tendency to wide divergence in form and color in the various groups and species furnishes to the true shell collector his chief source of interest and relaxation at home and a worthy excuse for any number of all-day rambles in the mountains. This point can better be appreciated by taking one or two fairly typical examples.

Color Varieties.

Extending over both sides of the mountains back of Honolulu, from Niu Valley to and including Makiki Valley, are distributed the species and varieties of what for convenience is known to some authors as the Fulgens group. To this group seven described species have been referred. But each of the so-called species ranges through a series of varieties sufficient in the opinion of

[2] The exact number varying with different authorities.

some to unite it very nicely with other species in the group. Under one species[3] are described no fewer than forty-two color varieties! Some are bluish-gray, others ashy-chestnut with black bands. Some are with two bands, others have three. Others are white or yellowish at the base, reddish-gray above, with a dark spiral line between. Others, again, are smaller and more elongatedly ovate. Still others are thinner than the typical varieties. Some have the spire more convex and colors less streaked, and so on, to the end that almost every specimen collected is found upon close examination and comparison to vary, much or little, from its next neighbor. But, unfortunately for the collector, this remarkably variable species, name and all, in the opinion of a second authority, is reduced to the rank of a synonym under the name of one of the other species[4] in the Fulgens group of our first authority, and in company with a species[5] from Waimea Valley, at the extreme opposite end of the Koolau range that has been carefully referred by our first authority to an entirely separate group, the range of the species is thus made to extend over this chain of mountains from end to end!

With such confusion in almost every species, it is little wonder that all those who collect Hawaiian land shells—and there are those in Honolulu who have private collections numbering into scores of thousands of specimens—are looking patiently forward to the completion of the work* by the more

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NOTE:—Since the manuscript for this chapter was written, Volumes XXI (1911) and XXII (1912-1914), and a more recent supplement to Volume XXI, of the Manual of Conchology have appeared. Both volumes are splendidly illustrated with colored plates and include synonomy and descriptive text treating fully the Hawaiian terrestrial *Amastridæ* and the tree-dwelling *Achatinellidæ*. This review of these interesting families of land mollusks by Dr. Henry A. Pilsbry, with the assistance of a number of local collectors, has been anxiously awaited by students and conchologists generally. The volumes are in every way praiseworthy, and are indispensable to those who are interested in this section of the Hawaiian fauna.

Volume XXI is devoted to the sub-family *Amastrinæ*, which in the subsequent volume is elevated to full family rank (**Amastridæ**). It is made to include seven Hawaiian genera, namely: *Leptachatina*, with 117 species and a number of sub-species; *Carelia*, with eleven species and nine sub-species and varieties; *Pterodiscus*, seven species, two sub-species; *Planamastra*, two species; *Armsia*, one species; *Amastra*, 114 species with numerous sub-species and varieties; *Laminella*, fourteen species and six sub-species and varieties, the last genus being arboreal in habit.

Volume XXII treats fully of the true **Achatinellidæ**, recognizing three well-defined genera, namely: *Newcombia*, *Partulina* and *Achatinella*. The *Partulina* are further divided into four (*Perdicella*, *Partulina*, *Baldwiniana*, *Eurnella*), and the *Achatinella* into three (*Bulimella*, *Achatinellastrum*, *Achatinella*) sections. The genus *Newcombia* includes nine species and three sub-species; *Partulina*, fifty-one species and a number of sub-species, varieties and forms; and *Achatinella* forty-one species with a very large number of sub-species and minor forms. In the appendix to Volume XXII, and the supplement mentioned, as many as two score of species and sub-species are described, in addition to the large numbers of new species described in the text of the volumes. They are divided quite equally among the various genera in proportion to the number of forms already known, and represent graphically the progress made during the period (1911-1915) of publication towards a more complete systematic knowledge of the land shell fauna of the group. The rapid increase in new species indicates that the possibility of collecting new forms is by no means exhausted. A comparison of the text and synonomy of these later volumes with the earlier (1900) work of Mr. E. R. Sykes will show the sweeping changes that have taken place in the nomenclature during the period of fifteen years.

It is to be hoped that the remaining families of Hawaiian air-breathing mollusks (*Pulmonata*) may receive a similar review by the author of these epoch-fixing volumes at an early date.

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[3] *Achatinella plumata.* [4] *Achatinella buddii.* [5] *Achatinella cæsia.*

recent and most painstaking authorities, the renowned Dr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia, and the local specialist, Dr. C. Montague Cooke, of the Bishop Museum. It is hoped that their conclusions as published from time to time, since they are based on extensive field collections and the examination of the hundreds of thousands of shells now in museum collections, will at least settle once and for all the question of "which is which" in the shell fauna of these islands.

But we cannot afford to pass without comment in this connection the interesting investigation of my friend and colleague, Dr. Cooke, on the distribution and variation of a single species[6] of Achatinella from Nuuanu Valley, published by the Bishop Museum.

For his purpose he selected a shell from Nuuanu Valley that, as a recognizable species, seemed to be fairy abundant and is commonly regarded as occurring only in that single valley. The northwest side of the valley was carefully explored and about three thousand shells collected, over half of which belonged without question to the single species under investigation. Beginning at the upper end of the valley, at the famous Nuuanu Pali, the habitat studied included the main ridge on the left and the sub-ridges and valleys that extend into the main valley of Nuuanu from one hundred to three hundred yards at almost right angles to the main ridge. On account of the sedentary habits of the land snails, these ridges, owing to the deep valleys that separate them one from another, form isolated habitats. Of the twenty-three sub-ridges the upper seventeen were all found to offer a very uniform environment as far as food, moisture and elevation were concerned. All were found to be inhabited by the particular species of land shell being studied. In some instances the sub-ridges were further sub-divided into special localites so that the area of none of the localities was over one hundred and fifty yards in diameter. Specimens were found to favor the more open localities between one thousand and fourteen hundred feet elevation.

With the data and material at hand Dr. Cooke was able to describe twenty-five well-marked color varieties, all of which were more or less closely connected by intermediate specimens. When we remember that the species in its various forms is distributed over an area only a few hundred yards wide at most, by two or three miles in length, it is clear that much scientific interest must attach to such studies. Among many other interesting facts it was found that the shells varied not only from one ridge to another, but from one colony to another. In fact, the specimens secured from a given limited locality often varied among themselves to a remarkable degree.

It was the early appreciation and observation of facts such as these, and a desire to find the law that underlies such facts, that led my friend, the distinguished evolutionist, Rev. John T. Gulick, in his early youth to begin a systematic collection of land shells. Later, through the inspiration of Darwin's great book on "The Origin of Species,"[7] he set to work in earnest, with

[6] *Achatinella multizonata.* [7] Published in 1859.

PLATE 101. FRESH WATER FAUNA OF OAHU.

(For Description of Plate See Opposite Page.)

the result that he soon published a considerable amount of valuable data based on Hawaiian land shells, the object of which was to show that isolation, segregation and variation were exceedingly important and until then almost neglected factors in the theories advanced in efforts to explain the formation of natural species.

In the study of so small and apparently unimportant a subject as a land snail, Dr. Gulick's philosophic mind found abundant material for the elucidation of such profound subjects as the variation of species as related to their geographical distribution illustrated by the *Achatinellidæ* (1872); diversity of evolution under one set of external conditions; divergent evolution through cumulative segregation; intensive segregation; divergent evolution and the Darwinian theory; the inconsistencies of utilitarianism as the exclusive theory of evolution, and lastly the preservation and accumulation of cross-infertility (1890-97). All of these were contributions to knowledge of the most far-reaching significance.

Important Families Represented.

Scarcely less in numerical importance when compared with the genus *Achatinella* are the one hundred and fifteen or more species of the genus *Amastra,* representatives of which are distributed over all the large islands of the group. The *Leptachatina,* with an equally extended list of species, is likewise distributed; and so the enumeration could be extended, but it is not the intention in this place to attempt more than to encourage the beginner to enter this fascinating field of study, where so much has already been accomplished and where yet so much remains to be done before this remarkably rich and varied fauna will be completely understood.

In the gathering of these "jewels of the forest" the collector will find many forms occupying a great variety of habitats, so that bushes, grass, trees (including their leaves, trunks and limbs), the ground, dead leaves, the rocks in the streams, the streams themselves—in short, almost every conceivable place, but particularly the moist regions of the mountains—is liable to have its shell inhabitant. The great majority of those species found on the ground, however, are more liable to belong to some of the fourteen families other than the *Achatinellidæ,* but they will not be found entirely devoid of interest for

Description of Plate.

1, 2, 3. Chinese Snail (*Viviparus chinensis*). 4, 5. Melania (*Melania mauiensis*). 6, 7. *Melania mauiensis* (Badly eroded). 8, 9, 10, 11. *Melania newcombii.* 12. *Neritina vespertina.* 13. *Neritina cariosa.* 14. Pipipi (*Nerita picea*) on rocks at low tide. 15. Operculum from *Viviparus chinensis.* 16. Limnæa (*Limnæa oahuensis*). 17. Shrimp [Opae] (*Macrobrachium grandimanus*). 18. Dragon Fly [Pinau] nymph (Introduced). 19. Brackish water Crab (*Metograpsus messor*). 20. Native Dragon Fly [Pinau] nymph. 21. Shrimp (*Macrobrachium grandimanus*). 22. Water Beetles (*Hydrobius semicylindricus*). 23. Limnæa (*Limnæa binominis*). 24. Fresh water Clam (*Sphærium sp.*). 25. Water Beetles (*Rhanthus pacificus*). 26. Sow-bug (*Porcellio scaber*). 27. Waterboatman (*Arctocorisa blackburni*).

that reason. As many of them are scarcely an eighth of an inch in length, they require that careful search and much patience be expended in collecting them.

Among the more conspicuous of the various families, not included in the extensive divisions of the *Achatinellidæ*, are the *Succineidæ*. There is but the single genus[8] in the family, with perhaps thirty species known from the islands; the larger number being found on the Island of Hawaii. They are delicate thin-shelled mollusks with a slightly spiral shell, the last whorl of which is large and flattened, giving the empty shell the appearance of a twisted finger-nail. The majority of the species prefer damp situations, usually under luxuriant foliage, though there are species that vary their habitat somewhat. Another family[9] with very fragile spiral shells is represented by perhaps a dozen species of the genus *Limnæa*. At least half the known species are from Oahu. The best representative of the genus is the small shell[10] found floating on the surface of the water in taro and rice ponds about Honolulu. Other forms occur in the cool mountain water at high elevations; a horn-colored species[11] found on the rocks beside the waterfalls at the head of Manoa Valley furnishing a good example. *Erinna newcombia* is the only known Hawaiian species of this related genus; it was reported only from the Hanalei river, on Kauai, until the author collected specimens from the Limahuli stream.

A very minute cap-shaped shell[12] found in various streams on the under side of decaying leaves, especially the leaves of kukui and hau, also belongs in this group, although there is little in the shape of the tiny paper-like shell to suggest such a relationship. While they are fairly common and are quite generally distributed, on Oahu at least, they are very seldom seen even by expert collectors.

The conspicuous and abundant long spiral fresh-water shells common in the lower portion of the streams on Kauai, Oahu, Maui and Molokai are sure to belong to one family.[13] The six known species are all placed in one genus.[14] The species[15] with the entire surface roughened is the more widely distributed, being taken on all of the islands mentioned. The smooth species[16] has so far been collected on Oahu and Kauai, but both species often occur together in the same stream.

Some years ago the Chinese introduced an edible snail[17] which has become firmly established in the taro and rice ponds of Kauai, Oahu, Maui and Molokai, and doubtless on the other islands. Large specimens may be collected, often two inches or more in length, but as a rule they are seldom so large. They are, however, easily the largest species of land or fresh-water shells in the group and belong to a family[18] without other representatives in the islands.

The small globular snails[19] with short spires occurring in damp woods have as many as a dozen or more known species. They are the only representatives of the operculate shells in the land fauna; but as the largest

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[8] *Succinea.* [9] *Limnæidæ.* [10] *Limnæa oahuensis.* [11] *Limnæa binominis.* [12] *Ancylus sharpi.*
[13] *Melaniidæ.* [14] *Melania.* [15] *Melania mauiensis.* [16] *Melania newcombia.*
[17] *Viviparus chinesis.* [18] *Viviparidæ.* [19] *Helicinidæ.*

examples are less than a quarter of an inch in diameter, they are seldom taken by other than a specialist with a taste for collecting the small "pin head" groups of Hawaiian mollusks.

Occurring in similar localities with the species mentioned above are found the beautiful spiral, translucid, shining Opeas. A common species [20] occurs on all the islands, but as there are but four species belonging to the two genera in the family,[21] they are not regarded is important.

The streams, particularly towards their mouths, are liable to be inhabited by one or more of the five or six species of *Neritina* found in the islands. A large flat black species with an orange mouth and roughened shell [22] is found higher up in certain streams, adhering to stones. They are gathered for the markets, the finest specimens perhaps coming from Pelekunu Valley, on Molokai. All of the species are liable to be found on any of the islands, their occurrence apparently depending on the habitat. The several fresh and brackish-water members of this family [23] adhere to stones and other objects in the water, and all are eaten by the Hawaiians.

A very common coiled snail shell [24] that grows to be three-fourths of an inch in diameter, is common all over the island, but especially plentiful about Honolulu, where they occur under boards and flower pots, or in moist weather may be found slowly creeping about over the grass, fences, walks and shrubbery. They are the largest representatives of the Helix family [25] in Hawaii, and as this species is widely distributed, it is doubtless an introduced form. Specimens are abundant in scattered and isolated places on Oahu, indicating that it is by no means a new arrival.

During a period of drought the animal draws back into the coils of the shell and secretes a whitish paper-like false operculum over the aperture. They will live in this condition for many months, but in the rainy season they become active again.

The curious black slug,[26] about two inches in length with a pale line down the center of the back, is also an introduced species that at times is very plentiful about Honolulu. They are nocturnal in habit, coming out at night from moist places where they remain hidden during the day. Slugs often leave a trail of slime or mucous behind them as they creep along. They are supposed to feed upon decaying vegetation. Although an introduced species, it serves very well to represent the family of true slugs,[27] of which there are five or six species known from the mountains on the different islands. They are not abundant, however, the most common native slug [28] on Oahu being a small species that occasionally occurs in the mountains of Kauai and Maui.

While the species of several families of Hawaiian shells [29] are too minute to be often seen or to admit of a brief characterization, they are, nevertheless, sure to occur in the material gathered by a careful collector. Probably between seventy-five and one hundred species of Hawaiian shells are placed in the

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[20] *Opeas junceus.* [21] *Stenogyridæ.* [22] *Neritina granosa.* [23] *Neritidæ.* [24] *Eulota similaris.*
[25] *Helicidæ.* [26] *Veronicella* sp. [27] *Limacidæ.* [28] *Agriolimax bevenoti.*
[29] *Zonitadæ, Philomycidæ, Endodotidæ, Pupidæ, Tornatellinidæ.*

various families here grouped as being too small to be illustrated or to receive notice in a book of this character.

The tiny fresh-water clams[30] are represented, so far as known, by a very minutes species[31] and a still smaller form[32] on Oahu, Molokai, Kauai, and perhaps other islands of the group. Both of these forms are very small, the larger being less than two-tenths of an inch in diameter.

Earthworms.

The worms of the islands have never been exhaustively studied. A dozen species of earthworms[33] representing three genera are enumerated by Dr. F. E. Beddard, who examined and reported on the material collected by Dr. Perkins. The species occurring in cultivated grounds appear to have been transferred to the islands by man. The leeches[34] have not been studied. Two species are quite common in the streams of Oahu, and there are doubtless other species on the different islands. But in general the fresh-water streams of Hawaii have received but little attention from zoölogists, doubtless owing to the fact that they are known to be very sparingly inhabited by animals of any considerable size, save a few fish and fresh-water shrimp. Of recent years, however, frogs, tadpoles, mosquito fish and dragon-fly larvæ have added a welcome touch of life to the streams.

CHAPTER XXXIV.

SHELLS FROM THE SEA-SHORE: PART ONE.

Pleasure of Collecting Shells.

A ramble by the sea-shore usually results in gathering shells, seaweed, fragments of coral and such odd remnants of life as are cast up by the waves, and it is from the desire to know more of the natural history of such objects that many a person has been led into the systematic study of the life of the sea and thereby become a life-long student of nature. To one with a taste for such pursuits, the sea-shore of the Hawaiian Islands furnishes a never-failing and ever-changing lure. Winter or summer, day or night, one may wander up and down the beach or wade in the shallow water for miles, knowing that he can never grow too old nor become too full of knowledge to enjoy nature's open school by the sea-shore.

The class of objects most liable to attract the novice are the dead shells strewn here and there along the sandy beach. Little by little one comes to realize that there are many different kinds of shells, and that realization usually is the starting point of the collection of shells, for one soon appreciates the necessity of specimens for comparison; and the pleasure of adding little by little to the storehouse of one's treasures by one's own efforts is a pleasure that has in it all of the joys of discovery, knowledge and possession.

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[30] *Cyrenidæ.* [31] *Sphærium* sp. [32] *Pisidium.* [33] *Terricolæ.* [34] *Hirudinea.*

Persons coming to Hawaii imbued with the idea that the shores of all coral-wreathed islands in the tropics are piled high with large and showy shells, such as adorn the curiosity dealers' windows throughout the country, and that are often labeled "from Hawaii," or more often the "Sandwich Islands," are sure to be disappointed. Such shells are usually gathered from islands far to the south of Hawaii. They are labeled "from Hawaii," not so much from a desire to give their proper locality, a thing the collector soon learns to appreciate as a matter of very great importance, as to make of them mere "curiosities," something rare and strange to sell to the unsuspecting. For that reason it is better to collect such specimens as one can gather, even though they are not as large or brilliant as those one can buy, and exchange such duplicates as are gathered with associates, be they schoolmates, traveling companions or professional collectors.

The first expedition, perhaps a stroll along the bathing beach at Waikiki, is an auspicious one if two dozen different kinds of small beach-worn shells are gathered; for with shells, as with almost all forms of life, only the most resistant types can withstand the grinding action of the waves. If the same beach is visited the following day, a week later, or when opportunity offers, without doubt other species will be found; thus the little collection grows.

The enthusiast soon learns that different environments, as sandy beaches, rocky coasts, coral reefs, sheltered bays and the open coast line, are inhabited by different groups of mollusks and that in due time their shells are cast upon the shore. The pleasure and the profit in visiting the same localities and different localities under varying conditions at different seasons, again and again, soon comes to have a fascination that only those who have become enthusiasts themselves can understand in others.

Three Types of Mollusca.

So far as the writer knows, no one has ever succeeded in gathering a complete collection of all the shells that may be collected from the waters about the islands, or even from the shore of a single island. A complete collection would number many hundreds, if it were made to include all of the many-celled animals without a backbone and with unsegmented bodies, without paired, jointed appendages and with or without a hard shell, that are included in the great phylum Mollusca.

Such a group would include three widely different types of animals. The squid, the octopus and their kind,[1] in which the head is well developed and in which the front part of the foot surrounds the mouth and is remarkable for its bearing a series of lobes or tentacles—called the "arms" in the octopus—form one class.

The snails, slugs, whelks and periwinkles form a second class and are called Gasteropods. They are usually, though not always, with spiral shells, but they may be without shells at all. The name gasteropod means stomach-

[1] *Cephalopoda.*

PLATE 102. TWO MOLLUSKS USED BY HAWAIIANS AS FOOD.

1. An Octopus or Devil Fish [Hee] (*Octopus sp.*) as seen at the Aquarium. 2. Hawaiian gathering Pipipi (*Nerita picea*) from the rocks at low tide.

foot, and is an allusion to the fact that the entire lower portion of the body is thickened and flattened to form a broad muscular foot adapted to their clinging and crawling habits. In the common and more typical forms, the aperture, which is the opening into the spiral shell, is closed when the animal is retracted, by a small horny or shelly plate called the operculum, but both the spiral shells and the operculum are absent in certain gasteropods.

The third division [2] includes such creatures as the mussels, clams, scallops and oysters, in which a right and left valve or shell can be plainly recognized. For this reason they are commonly spoken of as bivalves. The living animal has broad, flat gills on each side of the body to which water is brought through a tube called the siphon. The food, consisting of minute plants and animals, is strained out of the water as it passes through the incurrent and excurrent tube. The bulk of the soft part of the animal is called the foot and is suited for digging.

Mussels, Clams, Scallops and Oysters.

While there are a number of species of bivalves in the waters about the islands, perhaps not more than fifteen or twenty species are common on Oahu. Of these the one most frequently met with is the common mussel,[3] which in many places, as at Diamond Head and Pearl Harbor, almost pave the shore below the low-tide mark. They are from an inch to two inches in length; the right and left valves are equal, slightly ridged, and are covered with an epidermis which varies from black to light yellow. The hinge has minute teeth, and the beak is at one end of the hinge-line. They live attached to rocks, shells, piles or other objects by a number of threads called the byssus. A species occurring in Europe is much esteemed as food. The Hawaiians use the nahawele, as they are called, but so far as the writer knows they have never been gathered for market.

A method formerly employed by the natives in preparing this common mollusk for food should be of interest to sea-shore campers. A spot was found where the mussels were exposed at low tide, and over the bed of shells, driftwood was piled and a fire lighted. The heat caused the shells to open and at the same time roasted the fleshy part within, rendering it very palatable. The natives also gathered them from the shallow water and placed them in wooden calabashes in which water was heated by means of hot stones. In a few minutes the animal would be thoroughly cooked. The water was then drained off and a pinch of sea salt added to bring out the flavor of the food.

The Mytilus, or edible mussel, is readily separated from the two or three common species of Perna, especially a small black form [4] which it somewhat resembles, by the more compressed form of the shell and by the several tooth-like notches along the straight hinge-line. The Perna are further marked by conspicuous flaky lines of growth which are important characters in the various common forms. One species, the papaua of the natives, common at

[2] *Pelecypoda* or *Lamellibranchiata*. [3] *Mytilus crebristriatus*. [4] *Melina = (Perna) californica*.

Kiwalao, is cream color with black teeth. A third species is dark-brown in color, with the hinge-line somewhat elongated and marked with fan-like lines radiating from the beak.

A species of the pearl oyster family[5] occurs at Pearl Harbor. The common species "pa" is often three or four inches or more across. The hinge-line in the common pearl oyster[6] found here is long and straight, without teeth, and is produced to form wing-like projections of the shell at either side of the beak, which is much nearer the middle of the hinge. Without doubt it was the presence of this shell with the iridescent interior, occurring at Pearl Harbor, on Oahu, that gave that sheet of water its name. Although they belong to the same sub-family,[7] they are not the famous pearl shell[8] of the South Pacific islands. However, a pearl-bearing species is found in Pearl Harbor and at certain other places about the group in the deeper water offshore, and pearls were found to some extent by the natives, but the pa was chiefly used by them for making fishhooks and to some extent in making the curious shell-eyes for their wooden gods.

Fine specimens of the chest or ark shell,[9] locally known as kupukele, are to be found living in the water and bedded in the solid rock in certain localities in the uplifted coral reef about Pearl City. They, in common with other species of the family,[10] have the beak near the middle of the hinge. The hinge-line is strong and straight and is furnished with fine interlocking teeth. The outside is fluted with pronounced squarish riblets. A second species[11] found washed up on the sand beaches is oblong in shape, and in the dead shell the whitish surface is marked with many fine riblets which in old age become broken up into squarish points by the lines of growth. The inside of the shell within the pallial line is also roughened by lines radiating from the beak.

The true oysters, the scallops and the saddle oysters differ from other bivalves in that they have but one, instead of two, adductor muscles for pulling the shells together. They lie on their sides instead of standing on edge as other bivalves do, and the under valve becomes flattened or otherwise modified in consequence.

There is a large species of extinct oyster[12] to be found in the uplifted beds about Pearl Harbor, but there also occurs a smaller living species[13] seldom more than two inches in length. On account of its sharp edge it is called pioeoe by the natives. It makes a rough, rude, irregular foliated shell, the edge interlocking by numerous notch-like folds. They are too small and scarce to be used extensively for food. Nevertheless, they, and their extinct cousins, indicate that a commercial species could be grown in the islands if the proper kinds were introduced and proper care taken in their planting, despite the fact that efforts in this field have so far proved unsuccessful.

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[5] *Aviculidæ.* [6] *Margaritifera fimbricta.* [7] *Aviculinæ.* [8] *Avicula margaritifera.*
[9] *Arca.* [10] *Arcidæ.* [11] *Arca candida.* [12] *Ostrea retusa.* [13] *Ostrea rosacea.*

Attempts at Oyster Culture.

In 1871 the first attempt was made to introduce the Eastern oyster[14] into Hawaii. Again in 1883, Mr. Allen Herbert purchased three hundred Eastern oysters in San Francisco and planted them in Kalihi Bay, but heavy freshets in the stream covered them with mud. In October, 1893, another attempt was made. This time one thousand Eastern and three thousand California oysters[15] were secured in San Francisco and planted in ponds at Ewa in shallow water. In a very short time the California oysters died. The Eastern oysters thrived better, and by 1895 Mr. J. F. Colburn undertook a more extensive planting. More than thirty-eight thousand oysters were planted in that year, but they did not thrive, and by 1901 only a few living shells could be found.

Next to the oysters come the pretty scale-like golden saddle oyster (pipi) or Anomia shells. The common species[16] are irregular in form and the valves are unequal. The lower and usually the flatter valve is remarkable for the hole near the hinge through which a plug-like peduncle passes by which the shell is attached to other shells or rocks. Fine specimens occur about Ford's Island, at Pearl City, and are to be found in suitable places in other localities.

The scallops or pectens,[17] of which two or three species are quite common, as well as a related genus,[18] are more regular and symmetrical in the growth of the shell. They are usually flushed with rose color and ornamented with radiating ribs. The wing-like ears together with the symmetrical outline of the shell renders the genus[19] an easy one to identify, and as the species are fond of sandy bottoms and shallow water their shells are scattered here and there along our beaches. The shell of Hinnites is irregular in growth. As they are usually attached to some submerged object, they are less commonly found on the shore.

Coming to the clam-like mollusks of the islands, first place should be given to the olepe[20] by reason of its being the most important shell-bearing food mollusk of the group, though the present day Hawaiians apply the same name indiscriminately to a number of edible bivalves that are in no way closely related to the common species. Full-grown specimens of the olepe are two inches or more in length and are creamy white in color. They are slightly flattened, but are rounded in front and angular and slightly folded posteriorly. The shell is beautifully sculptured with wavy lines which become more and more pronounced as the shell advances in age. They are fond of burying themselves in the soft mud at the mouths of rivers and have long been an article of food especially prized by the Hawaiians. A smaller, smoother, more delicate milk-white species[21] known by the same name by the natives is often found in large numbers on the sandy beaches on the windward side of Oahu.

A small, round, white clam[22] also occurs in Pearl Harbor, both as a living

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[14] *Ostrea virginica.* [15] *Ostrea lurida.* [16] *Anomia nobilis.* [17] *Pectinidæ.* [18] *Hinnites giganteus.*
[19] *Pecten.* [20] *Tellina rugosa.* [21] *Tellina dispar.* [22] *Cadokia = (Lucina) ramulosa.*

and a fossil species. It has its firm shell sculptured with a large number of radiating riblets, and the margin minutely roughened or crenulated.

The genus *Cytherea* is represented by a heart-shaped clam [23] that is similar to the Venus clam but is much rounder and thicker. Like it, the hinge has three strong teeth, but the species has its surface beautifully marked with radiating blotches of brown. These markings, however, often disappear from beach-worn specimens, or in old age, leaving the pure white shell slightly roughened with minute hair-like growth lines. The markings are responsible for the common name tent or encampment shell.

In Hawaii, as elsewhere, one of the commonest forms of clam shell everywhere along the beach is a species of Venus [24] or round clams. Its stout white shell is beautifully roughened by prominent concentric bands which are broken up into numerous rectangular spaces by the radiating rib-like lines.

The typical species of Cardium or heart shell [25] found on Oahu is easily identified by its heart shape when both valves are joined, and by the strongly convex valves, which are deeply ribbed, the ribs interlocking on the margin of the shell. In addition to the center teeth there is also a strong tooth at the extreme end of the hinge line. The inner surface shows the furrows of the rib lines, and even in beach-worn specimens it is of a delicate pink color.

Several species belonging to the family of rock oysters [26] are found on the beaches, as they are fond of attaching themselves to various objects, especially the dead and growing coral. At first glance they may be mistaken for oyster shells, but their thick, heavy, solid, foliated shell is somewhat spiral at the tip and the unequal valves are united by teeth, two in the left, or attached valve, and one in the upper, or lid valve. The name of the genus [27] has reference to their gaping appearance. Some of the specimens are four inches in length and the two valves together often weigh a pound. The inside of the shell may be white or colored, especially about the margin, with rose, lavender or brown. As they are very thick and strong, they long withstand the grinding of the sea and sand, and fragments lie along the shore which are worn down perfectly smooth. Other specimens are much roughened by numerous small holes drilled in the shell by various worms which enter them for protection. They are sometimes used as food by the natives, either cooked or raw, and are known to them as kupakala.

Gasteropods, Including Snails, Slugs, Whelks, Cowries, Etc.

In a book of this character it is obviously impossible to give more than the briefest mention of some of the more common and interesting of the several hundred species of gasteropod mollusks that have been reported from the Hawaiian Islands. However, it is hoped that by reference to the accompanying figures and the brief description given of the more common species occurring in the waters about the islands, that many of the shells found along the shore

[23] *Lioconcha hieroglyphica.* [24] *Venus reticulata.* [25] *Cardium orbiter.* [26] *Chamidæ.*
[27] *Chama.*

may readily be placed in their proper genera by those who do not have access to more minute description. To make the illustrations more useful to those whose collections are made mainly from the beach, the majority of the specimens shown are in the beach-worn condition in which they are liable to occur. They were selected from material collected on four holiday excursions, one to Waikiki and Diamond Head, one to the dredger-dumped material from Honolulu harbor, one to Pearl Harbor and one to Kahana Bay. Ninety-two species belonging to forty-one genera were collected in this way. Of this number sixteen species belonging to fifteen genera are included in a list of forty-five species reported by Mr. D. Thaanum as commonly found on shore and in the shallow water about Hilo. Mr. Thaanum's collection, which includes the land and fresh-water shell collection made by the Kuhns brothers, is one of the largest and most systematic private collections in the islands. The marine collection numbers upwards of two hundred and fifty species belonging to ninety of the one hundred and twenty or more genera commonly included in a list of Hawaiian gasteropods.

As an example of the unusual reward to be had for more exhaustive collecting in a given locality for a single group of shells, it is interesting to report that Mr. J. M. Ostergaard has been able, in a few years, to secure from the dredging from Honolulu harbor and other sources, thirty of the forty species and sub-species of the beautiful *Cypræa*, or cowry family, so far listed in the literature of the subject as occurring in the Hawaiian Islands.

The univalve or gasteropod mollusks are by far the largest division of the Mollusca. Some are free swimming animals, living far from land out in the open seas, but the greater number inhabit shallow water, usually about the low-tide mark; while others dwell in brackish water, in fresh water and on the land. The typical gasteropod—and it is only this division that can be considered in any detail here—is normally a crawling animal bearing a coiled shell. They all move slowly by the continual contraction and expansion of the muscular foot. Many of the common marine forms have interesting habits, and may be kept alive with very little trouble in a simple salt-water aquarium. In a small aquarium one should be careful not to overstock. Two or three healthy, happy specimens are less trouble and far more interesting for the purposes of observation and study.

In general it will be found that the species that have the base of the aperture rounded as in *Littorina, Crepidula, Nerita* and the like, are herbivorous in habit, feeding on seaweed, moss and minute aquatic plants. Shells in which the aperture is deeply notched or prolonged into a canal, as in *Nassa, Strombus, Mitra* and *Cypræa*, are usually carnivorous or flesh-eating species and are perhaps more difficult to supply with their accustomed food on that account.

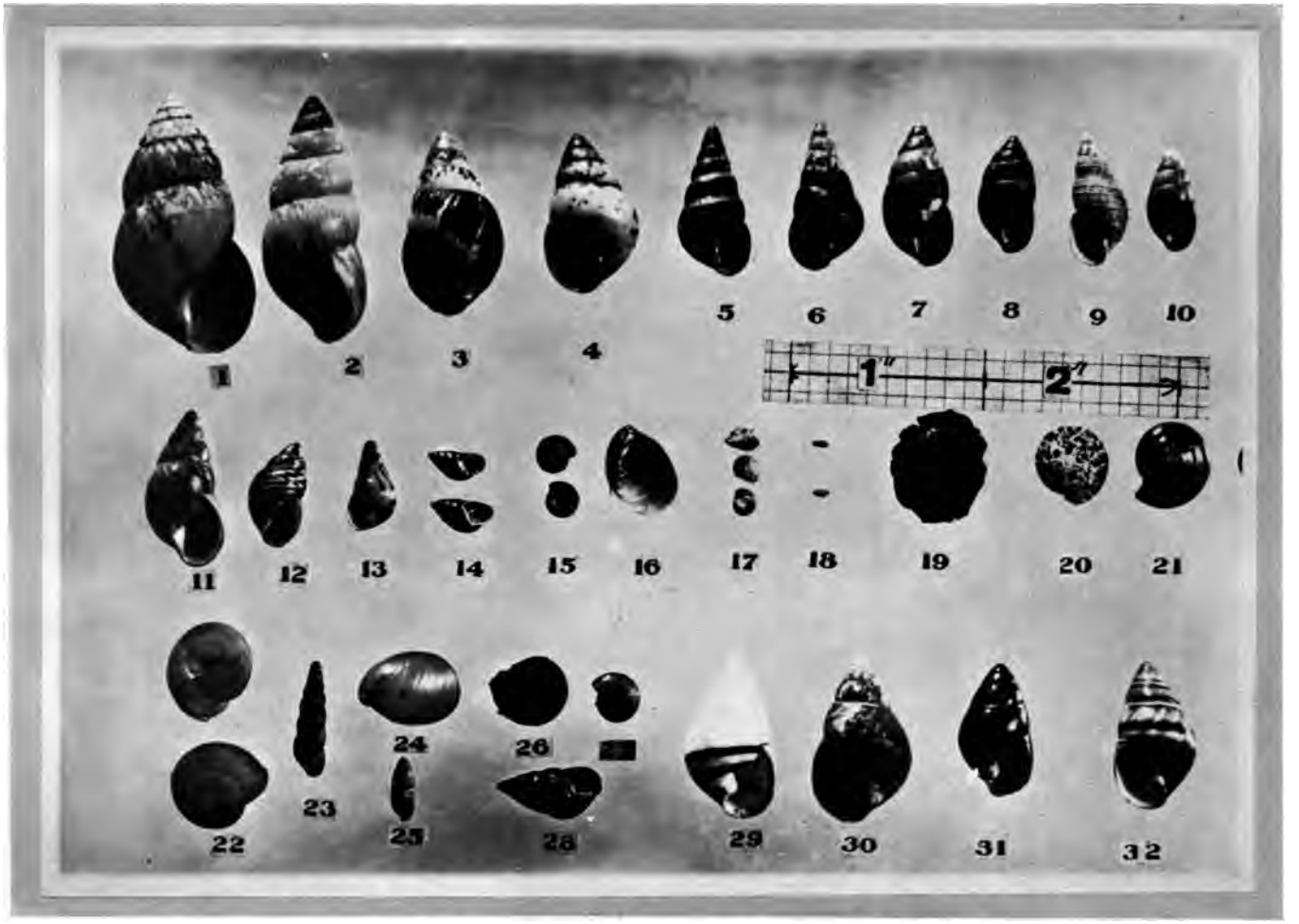

PLATE 103. IMPORTANT GENERA OF LAND SHELLS.

(For Description of Plate See Opposite Page.)

Spiny Rock Shells.

The extensive family [28] known as the spiny rock shells is represented in Hawaii by ten genera with perhaps twenty-eight or more species. The typical genus *Murex* is seldom found on the shore, but the genus *Purpura,* named in allusion to a purple dye formerly secured from certain species, has three species, one of which is quite common. These, together with the castor bean-pod shells,[29] the banner shells [30] and the rattle shells [31] shown in the plates, will be sufficient to give an idea of the more common forms belonging to this family.

Of the rattle shells there are several small species known from Hawaii. The mulberry shell [32] is appropriately named from its appearance. It is quite generally distributed, but is not conspicuous, since it is less than an inch in length. To these, and in fact to the great majority of shells of the same general shape, the Hawaiians gave the class name pupu. It seems that the number of species was so great that the natives applied specific names to only a few of the more important ones.

Tritons.

The triton family [33] is represented in the islands by a dozen or more species belonging to the typical genus [34] and as many as eight or more of the frog-shell [35] group, which differ from their cousins in having a pronounced ridge or varix on each side of the shell, which forms a thick ridge on the opposite sides making the shell distinctly two-edged. They live on the coral reef, and all but one of the species has been taken from Honolulu harbor.

The fine triton trumpet [36] is seldom taken on shore. But as they grow to splendid proportions and are the largest shell that occurs in Hawaii and were used by the ancient Hawaiians as a war trumpet, they are worthy of special mention. They are said to attain a length of eighteen inches, but specimens a foot in length are more commonly seen. Such shells are treasured as a real possession by the old Hawaiian fishermen, for they know how scarce they are and how hard they are to secure, living or dead.

The hard shell has a peculiar resonant quality. When the tip of the spire is cut or ground away and the shell used as a bugle (pu), it emits a peculiar

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[28] *Muricidæ.* [29] *Ricinula.* [30] *Vexilla.* [31] *Sistrum.* [32] *Sistrum morus.* [33] *Tritonidæ.*
[34] *Triton.* [35] *Ranella.* [36] *Triton tritonis.*

Description of Plate.

1. *Amastra violaceæ var. wailauensis.* 2. *Carelia sinclairi.* 3. *Laminella gravida.* 4. *Laminella gravida.* 5. *Amastra turritella.* 6. *Laminella sanguinea.* 7. *Amastra rubricunda.* 8. *Amastra textilis.* 9. *Newcombia canaliculata var. wailauensis.* 10. *Leptachatina sp.* 11. *Partulina dubia.* 12. *Perdicella fulgurans.* 13. *Laminella venusta.* 14. *Auriculella sp.* 15. *Endodonta sp.* 16. *Succinea sp.* 17. *Helicina sp.* 18. *Pupa sp.* 19. *Pterodiscus rex.* 20. *Endodonta sp.* 21. *Philanesia baldwini.* 22. *Eulota similaris.* 23. *Opeas pyrgiscus.* 24. *Succinea sp.* 25. *Leptachatina chrysalis.* 26. *Pterodiscus discus.* 27. *Philonesia sp.* 28. *Amastra frosti.* 29. *Achatinella (Apex) lorata.* 30. *Partulina confusa.* 31. *Bulimella bacca.* 32. *Achatenallastrum plumata.*

foggy sound that carries for a long distance. In former times it was a convenient instrument with which to summon the laborers from their slumbers, or, in more strenuous times, to cheer the faithful on to victory at arms. The gracefully tapering shell is variegated with buff, brown, purple and red in a very rich and characteristic pattern. The outer lip is toothed, and whitish, with double streaks of brown which soon fade into the ruddy aperture.

The more common species, especially in Honolulu and Pearl Harbor, is the hairy triton[37] known as pupu ole. It may be recognized by its bristly olive-colored epidermis. On beach-worn specimens this peculiarity disappears, leaving the whole exterior of the shell streaked with revolving bands and folds. In the tritons, as with most shells, as age advances the lip thickens and changes take place between young and old specimens which confuse even those who profess to considerable knowledge of the science which deals with the shell-bearing animals.[38]

The quilted triton[39] is a smaller, more solid species, seldom more than two inches in length, and is far from being the most common triton in the islands. It exhibits considerable variation in coloring and other characters, but is usually light or dark brown with the ribs and tubercles lighter, and there is sometimes an ill-defined whitish band on the large or body whorl. The nodulated teeth and the mouth of the shell are whitish and thickly enameled. The interior of the aperture is orange-red.

Spindle Shells.

The spindle-shell[40] family has a typical Hawaiian form in a graceful white species[41] in which the long canal equals, or exceeds, the spire in length. The species is fond of mud-flats, where it burrows in the soft deposits. For this reason it is a common shell in harbor dredgings. The chick-pea shells[42] and the genus *Peristernia* are common shells that are grouped in a sub-family[43] of the spindle shells, but to the ordinary observer, unacquainted with all the details of classification, they appear to have little in common with the more typical forms.

Whelks.

So far as is known, the whelk[44] family, which includes the fulgur shells commonly figured in books on sea shells, are represented in Hawaii by only a few small species. The family as a whole is described as thick, ovate or pear-shaped shells with a short canal and with the columella (the pillar around which the whorls or turns of a spiral shell revolve) without plications or folds. The sub-family[45] to which the island species belong is characterized as small heavy shells, usually less than an inch in length, with teeth on the outer lip and the columella rough and thickened. The pisa shells[46] and the tankard shells[47] belong to this group. They are few in number and difficult to place even by skilled collectors.

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[37] *Triton pilearis.* [38] Conchology. [39] *Triton tuberosus.* [40] *Fusidæ.* [41] *Fusus nova hollandiæ.* [42] *Latirus.* [43] *Peristerniinæ.* [44] *Buccinidæ.* [45] *Pisaniinæ.* [46] *Pisania.* [47] *Cantharus.*

Dog Whelks.

The dog whelk[48] family has four species occurring in the islands, all belonging to the one genus[49] of fish-basket shells. The name is given them from the resemblance of certain species to the tapering narrow-mouthed wicker baskets used in Europe by the fishermen in the fish and lobster business. The small notch at the base of the aperture is an important characteristic. They are predatory[50] in habit and are usually found near the shore. The largest species[51] is whitish, more or less blotched with yellowish-brown, and has the spire tipped with pink. The various species of the genus seem to intergrade to a remarkable degree. To the common small, light-yellowish or orange-brown specimens with a pale central band is given the name *Nassa hirta.* The one with narrow red revolving lines and irregular broad bands, a variable species, is called *Nassa gaudiosa,* while *Nassa splendidula,* smaller than the foregoing, is white, shining and distinctly granose, caused by the crossing of the longitudinal ribs by deeply incised lines.

Mitre Shells.

The mitre shells collected in the islands are usually included in the great genus which is typical of the family,[52] according to the best authorities, although this large genus is variously divided by other specialists. Three or four additional genera, including the small "gutter-tile" shells,[53] which approach the cone shells in general form; the little turret shells,[54] of which there are four or five species, and a small, slender representative of the genus *Thala* are regarded as forming good genera, but they all have characteristics that are common to the true mitre shells, and all may be known by their sharp spire and the conspicuous and strongly marked folds on the columella. However, their size and the character of the body of the shell varies greatly, especially in sculpture and marking. There are more than two hundred species of mitre shells in the tropics, and some of them are of large size and great beauty. Of that number more than three dozen species, most of them less than an inch and a half in length, have been reported as occurring in the waters about these islands. Of a possible twenty-six species, seventeen of the genus *Mitra* have been collected from Honolulu harbor by the author.

The living shells are gregarious[55] and avoid the daylight by hiding in the masses of coral on the reefs or by burrowing in the sand. At night, however, like many of their marine associates, they creep out to feed. Their heavy, hard shells will long resist the action of the waves, so that they are to be found among the small pebbles on the shore. On almost every ramble by the sea the careful collector may gather one or more species of these attractive shells.

By reference to the accompanying plates they can readily be identified as *Mitra,* a name given out of a fancied resemblance to a priest's mitre; but to

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[48] *Nassidæ.* [49] *Nassa.* [50] That is, feeding on other animals. [51] *Nassa papillosa.* [52] *Mitridæ.*
[53] *Imbricaria.* [54] *Turricula.* [55] Inclined to gather in companies.

describe the various species accurately, in a way to be of use in identifying the beach-worn specimens, is obviously a task beyond the scope of this volume.

Margin Shells.

The margin shell [56] family includes small shells related to the cowries and mitres. They are pear-shaped, porcelanous in appearance, and are marked by the large body whorl. The aperture is usually nearly the whole length of the shell, and the outer lip has a narrow thickened margin which may be toothed or smooth within, but the columella is distinctly plicated much as in the mitre family.

Since the largest of the four species of margin shells so far collected in Hawaii is less than a fourth of an inch in length, they are liable to be secured only by those accustomed to close observation. The largest species [57] is smooth, pale rosy-white, with two brownish bands, and has the outer lip slightly thickened in the middle. It is the only species belonging to the genus taken here, but is, of course, too small for satisfactory photographic illustration. The typical genus of margin shells [58] embraces perhaps two hundred and fifty species. Of this number a dozen or more are Polynesian, three being credited to this group, two of which have been taken on Oahu. They have the outer lip conspicuously thickened, with the inner margin smooth, ridged or toothed in different species.

Olive Shells.

The olive shells are rare in Hawaii. The family [59] is so far represented by four species, none of which seem to be common. Only the beautiful conoid harp-shell [60] is commonly collected. This species, which shares the Hawaiian name pu with the triton shell, belongs to an important sub-family [61] in which the species differ from those in the typical sub-family [62] in several important respects, among them being the conspicuous and characteristic longitudinal parallel ribs on the shell. These ribs, together with the general harp-like shape of the shell, amply justify the common name. The color scheme is brown in many shades, and the pattern, resembling the banding of an agate, makes of the harp shell an object greatly admired.

The typical olive shells are smooth, solid, highly-colored, and agree with the group just described in having the outer lip simple and the aperture obliquely notched below. The red-mouthed olive [63] is a typical species. It has a deep orange-red aperture, and the pale creamy ground is variously banded with chestnut, but the general color scheme varies greatly. The species is said to inhabit muddy sand in deep water, where it attains a length of two or three inches. A small species of olive [64] less than an inch in length, is white within and without, and is marked with two wide and one narrow rich orange bands. It is a common wide-ranging species and together with a third undetermined species has been collected by Mr. Thaanum on Hawaii.

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[56] *Marginellidæ.* [57] *Erato sandwicensis.* [58] *Marginella.* [59] *Olividæ.* [60] *Harpa conoidalis.*
[61] *Harpinæ.* [62] *Olivinæ.* [63] *Oliva erythrostoma.* [64] *Oliva carneola.*

Dove Shells.

The little "dove shells" belong to a tropical family[65] to which more than eight hundred species have been referred by conchologists. Of that number fifteen or more species belonging to two genera have been reported from these islands. Among so many similar forms the characteristics distinguishing the species are often obscure and confusing. This is especially true in the present family, as the largest species are scarcely an inch in length, while the great majority are less than half that size. However, they are all solid shells of varying form with short anterior canals. The inner lip anteriorly is usually tuberculated; the outer lip as a rule is thickened and variously roughened on its inner margin. The most abundant and best known representative of the family in the islands is the little Niihau shell.[66] It is a trifle over a third of an inch in length and varies greatly in the markings and sculpture of the shell, but usually has the base of the columella stained with chocolate. These pretty bead-like shells, especially those from the Island of Niihau, were formerly used by the Hawaiians in making shell necklaces or leis. Necklaces made from them are still manufactured for sale and are much prized by tourists.

A slightly larger, and perhaps more typical form, is shown in *Columbella turturina*. It is white, variegated with clouds of yellowish-brown. The columella and teeth of the outer lip are usually stained with violet. The zebra dove shell[67] has a higher spire and the white ground is so curiously marked with zebra-like chestnut markings that it always attracts attention along the beach in spite of its small size.

A genus of "grey" shells[68] with three species, one of which Mr. Thaanum includes in his manuscript list of Hawaiian shells as occurring on Hawaii, and which also occurs on Oahu, is included in this family, though it is admitted that they bear but little resemblance to the typical genera. They are all longitudinally ribbed, the ribs broken up into nodules by revolving lines. The form *Engina farinosa*, a yellowish-brown shell with indistinct dusky bands, is found on Hawaii and doubtless elsewhere in the group.

CHAPTER XXXV.

SHELLS FROM THE SEA-SHORE: PART TWO.

The Cone Shells.

The cone shells[1] are sufficiently characterized by their common name to need no further general description than to say that in addition to being cone-shaped, the aperture is long and narrow, the lips are straight and parallel and are always without teeth or ridges. Perhaps four hundred species are

[65] *Columbellidæ.* [66] *Columbella variana.* [67] *Columbella zebra.* [68] *Engina.* [1] *Conidæ.*

known to occur in the tropical waters of the globe. Of this number one hundred and thirty-three are enumerated by one authority as occurring in the Eastern Asiatic province in which the Hawaiian Islands are included. Twenty-five species and well-marked varieties have been recorded from this group. Specimens of all but three of the Hawaiian species Mr. Thaanum reports having personally secured, chiefly in the vicinity of Hilo, while the writer has secured a similar number of species on the Island of Oahu. In the little collection of common beach shells secured on the four excursions mentioned are ten species ranging in size from tiny shells less than a half inch in length to heavy solid specimens three and a half inches long. Unfortunately most of the beach specimens secured are badly worn, in some cases past positive identification. The great weight of the dead shell in proportion to its size makes its progress over the wave-swept reef much slower and the grinding much more severe than would be the case with a lighter shell that might be caught up and laid down again high on the sandy shore, well out of harm's way, by a single wave.

The cones are fond of the coral reefs and hide in holes in the rocks on the reef and along the shore. They are carnivorous animals, and move slowly about seeking their food, which is usually obtained by means of curious poison fangs by which they paralyze their prey.

The most common and without doubt the most beautiful of the cone shells found in the dredgings from Pearl Harbor and Honolulu harbor is a species identified as *Conus quercinus*. The shell itself is a delicate tan color and is ornamented with numerous parallel revolving pen-lines of brown. Over this in fresh specimens is a thin rich-brown epidermis. They appear to prefer the muddy brackish water conditons at the harbor mouth to a life on the coral reef in the open sea. A more ordinary type of marking is found on the spotted cone shell.[2] It is about two inches long and has the creamy white ground irregularly covered with chocolate spots about the size of a pin-head. These spots are somewhat thickened towards the ends, thus forming three ill-defined bands about the shell.

The Hebrew cone[3] is so called from a fancied resemblance of the large deep-chocolate colored markings on the white ground to the characters used in the Hebrew alphabet. It is an inch and a half in length and is a reef-dwelling species, found usually on sandy shores with fragments of broken shells and other debris.

The largest species is the lettered cone,[4] which bears row after row of oblong brown characters on its white surface. A yellow undercolor groups these rows into indistinct bands. Specimens seven or eight inches in length are not uncommon, especially on the coast of Molokai, and a number of very large specimens come up in the dredgings of Honolulu harbor.

Unfortunately the worn specimens of any of the cones can seldom be identified without reference to perfect examples. The local collector should have no trouble, however, in identifying any shell he may secure by use of

[2] *Conus pulicarius.* [3] *Conus hebræus.* [4] *Conus litteratus* var. *millepunctatus.*

the labeled specimens in the extensive collection of Hawaiian shells at the Bishop Museum.

Leis were occasionally made by the Hawaiians of certain species of cone (leho) shells, but as a rule they were too scarce to be much used, although there is a string several feet in length in the Bishop Museum and the author has two such leis in his private collection.

Auger Shells.

The auger shells[5] are most appropriately named, for the long, tapering, many flat-whorled spire at once characterizes them, while the small aperture, notched in front, renders them easily placed in the single genus to which about two dozen Hawaiian species belong. These hard, sharp-pointed shells were of much use to the Hawaiians in various ways. They were formerly used as drill points in their crude but ingenious rotary drills. There they served their true purpose of an auger, but the hard, sharp outer lip was equally effective as a tool when used as a scraper. They made excellent stoppers for the small-necked gourds that once were used for the storage of water.

Even the fragment of the crenulated auger shell[6] washed ashore is sufficient for the identification of this large species in which the whorls are obtusely nodulated below the suture.[7] Fresh specimens are cream-colored, streaked with chestnut between the nodules, and with three revolving rows of chestnut spots on the body-whorl and two rows on the remainder of the spire. Adult specimens are five inches in length. The spotted auger shell,[8] when fully adult, is almost as large as the foregoing, but is orange-brown with a row of large white spots just below the suture and a second row below the middle of the body-whorl. The largest species occurring in Hawaii is *Terebra maculata*. Specimens in the writer's collection vary from three to nine inches in length. Large shells were much sought for by the natives, as they were fond of the animal and used the chisel-like edge of the shell in scraping out the wooden hulls of their canoes.

Perhaps the Gould auger shell[9] is the commonest species found on our Hawaiian sand-rimmed bays. It is a smaller species and one of a large number of this group of shells which is peculiar in that it has what appears to be a double suture about the spire. This band is slightly nodulated, while the body of each whorl is longitudinally plicated. The shell is creamy-white banded with very pale chestnut, and has three bands on the body-whorl. The cancellated auger shell[10] is smaller and has the narrow nodulous band white. To the unpracticed eye it is otherwise very similar to the preceding form.

A fifth form which is fairly common on sandy shores is *Terebra aciculina*. It is about an inch and a half in length, varies in color from deep chocolate to pale ash color, and is white-banded at the suture, as well as on the free edge of the body-whorl. Perhaps twenty species of auger shells can be secured in

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[5] *Terebridæ*. [6] *Terebra crenulata*. [7] The line where the whorls of the shell unite.
[8] *Terebra oculata*. [9] *Terebra gouldi*. [10] *Terebra cancellata*.

PLATE 104. COMMON MARINE BIVALVES.

1. Hawaiian Edible Mussel [Nahawele] (*Mytilus crebristriatus*). 2. Ham Shell [Hihiwai] (*Melina* = (*Perna*) *californica*. 3. Papaua (*Perna sp.*). 4. Papaua (*Perna sp.*).

(Description of Plate Continued on the Opposite Page.)

Hawaii by a careful collector, but as many of them are small and rare, their description would be out of place here.

Conch Shells.

The typical conch shell family[11] has but nine species reported from Hawaii, the most common species being the little spotted conch,[12] the puleho of the Hawaiians. They are found usually in the shallow water along shore, hidden away during the day under a coral rock or in crevices in the growing reef. The species is less than an inch and a half in length, and can hardly be made to agree with one's notion of this family founded, usually, on the fine large conch shell that everywhere, a generation ago, adorned the mantel, held the honored place in the curiosity cabinet or served a useful and ornamental purpose as a door brick in the homes of people not given to the pursuit of natural history. Nevertheless, if the species were compared it would be found that they differ mainly in size and color. They have the same solid shell, with a well-developed spire, the thickened, expanded outer lip similarly lobed; the columella without plaits and the posterior canal well developed. The living shell has a strong muscular foot adapted to leaping; a peculiarity which makes them interesting inhabitants for an aquarium. The shell of the common species, when the epidermis is removed, is creamy white, spotted and maculated with chocolate and orange-brown, and has the aperture white. *Strombus hellii* is a smaller yellowish-brown species regularly ribbed and crossed by spiral striæ. *Strombus samar* is larger and the outer lip has three large teeth, and the interior of the aperture radially ridged.

The only species of spider shell[13] so far found in the islands is five or six inches in length. They are stromb-like, but have the outer lip exaggerated by long curved fingers that make the mollusk look like a huge spider traveling on seven legs.

The Cowry Family.

The cowry[14] shells are all so well known to everyone who visits the seashore that a description seems unnecessary. The living animal is interesting, since from the long, narrow, centrally-located aperture emerges the curious, often brilliantly-colored, foot and mantle. The latter when fully expanded almost envelops the smooth, glossy shell. The young shells almost always show a short spire, but as they mature the spire is usually enveloped by the growth of the body whorl.

[11] *Strombidæ.* [12] *Strombus maculatus.* [13] *Pterocera aurantia.* [14] *Cypræidæ.*

(Description of Plate Continued from Opposite Page.)

5. Pearl Oyster [Pa] (*Margaritifera fimbriata*). 6. Ark Shell (*Arca sp.*). 7. *Arca candida.* 8. Hawaiian Oyster [Pioeoe] (*Ostrea rosacea*). 9. Jingle Shell (*Anomia nobilis*). 10. *Anomia nobilis* (young). 11. Scallop (*Pecten sp.*). 12. Scallop (*Pecten sp.*). 13. Purple-hinged Scallop (*Hinnites giganteus*). 14. Tellen Shell [Olepe] (*Tellina rugosa*). 15. *Tellina dispar.* 16. Hawaiian Cytherea (*Cytherea* = (*Lioconcha*) *hieroglyphica*). 17. Venus Clam (*Venus reticulata*). 18. Lucina Shell (*Cadakia ramulosa*). 19. Heart Shell (*Cardium orbiter*). 20. Rock Oyster [Kupakala] (*Chama sp.*). 21. Rock Oyster (*Chama sp.*).

Of a possible two hundred living species there are more than three dozen forms of these interesting mollusks reported as occurring in Hawaii, all of which are known as leho by the natives. With possibly one or two exceptions, however, they cannot be said to be abundant or common in the islands. Reference has been made in another connection to the large number of species belonging to this family that have been secured in Honolulu harbor. In the small collection of common beach forms, in the lot before me from Oahu, no fewer than ten recognizable species occur. Of that number three or four are sufficiently common to be liable to occur in almost every collection.

By far the most abundant species is the snake-head cowry.[15] It is seldom more than an inch and a quarter in length, and is often found along rocky coasts or in coral heads in shallow water. It is reddish or blackish-brown with unequal snow-like spots on the back. The extremities are tipped with white, the base gray; the teeth are strong and white. These and other species of cowries, especially the money cowry,[16] a small yellowish species, and another small form ornamented with white and brown spots, a saffron base and pale violet extremities, known as *Cypræa helvola*, were used by the Hawaiians to some extent in making their leis.

The hump-backed cowry[17] when full-grown is more than three and a half inches in length. Its brown color is varied by light brown or white spots of irregular size, while the sides and base are dark brown or almost black. The teeth are prominent and the edge of the shell is much thickened and angular. This fine shell is said to be the strongest and heaviest of the genus. It is one of the large sea shells in which the native children, like the children of many other lands, could hear the sound of the sea. It is a choice food of the Hawaiians and is often to be seen offered for sale in the market. Its shell was much used in making their ingenious squid-hooks. As a part of the hook the shell served as bait, and was attached to a stone sinker of similar size and shape, so that the flattened surfaces were together. Between the shell and the sinker there was fastened a stick, to the lower end of which was attached a hook of bone or, in more recent years, of iron. About the hook was usually fastened a bunch of leaves, which kept the point hidden from the eye of the cautious animal. The squid has a great fondness for this particular species of cowry. They seize the hook by wrapping their arms about the shell, when they are easily captured. "Humpbacks" (leho) were always in great demand among the fishermen for that reason. The flesh-colored cowry,[18] a large species ornamented with four or five deep flesh-colored bands and with a red animal, was also sometimes used as squid bait. The squid if captured under certain conditions by this species of shell, was supposed to be a very valuable remedy in the healing of the sick.

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[15] *Cypræa caput-serpentis.* [16] *Cypræa moneta.* [17] *Cypræa mauritiana.* [18] *Cypræa carneola.*

The following, translated by Dr. N. B. Emerson, is a portion of ancient pule repeated by the native doctor (kahuna) fisherman as the baited hook was lowered to capture a squid to be used for curative purposes:

"Here is the cowry,
A red cowry to attract the squid to his death.
Here is the spear, a mere stick,
A spear of lama wood for the squid that lies flat.
O Kanaloa of the tabu nights,
Stand upright on the solid floor!
Stand upon the floor where lies the squid!
Stand up to take the squid of the deep sea!
Rise up, O Kanaloa!
Stir up! agitate! let the squid awake!
Let the squid that lies flat awake, the squid that lies spread out."

Two large species related to the more familiar tiger cowry [19] (the largest of the family, and common in collections) have spots extended over the base. The Arabian cowry [20] has the base tinged with brown. If the spots are crowded and run together, the sides thick, and the base milky or bluish-white, with a dark blotch near the middle of the shell, it is the closely-related species *Cypræa reticulata*. All three species occur in the group, and, like most of the larger forms, were used as food by the Hawaiians. A small form usually about an inch in length, that is ashy-fulvous, without spots, and has the teeth white and the extremities saffron-red (that is usually collected in the group), is Isabella's cowry.[21]

A curious species of cowry, occurring quite commonly in the islands, belongs to the group in which the shell is covered with little nodules. It is a wide-ranging form, known as the Madagascar cowry,[22] and is a species in which the ridges on the outer lip are alternately large and small. The list of rare or occasional species could easily be extended into a small volume.

Five minute white or pinkish species of the coffee-bean shell [23] have been reported from Hawaii. As the largest of them are less than half an inch in length, they are seldom seen by amateurs. They are all cowry-shaped, rather roundish and curiously cross-ribbed shells that can at once be identified by their resemblance to the larger members of the family.

Egg Shells.

The egg shells [24] are so seldom seen on our beaches that a description of the species seems unnecessary, farther than to say that in general form they resemble the cowries, are whitish or dull in color and the extremities are usually drawn out to form two canals. They differ from the family mentioned above in having the inner or columella side of the aperature smooth. The shells occur throughout Polynesia, where in many of the islands they are much prized as personal ornaments.

Tun Shells.

The tun shells,[25] or wine jars, as the name given to the family signifies,[26]

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[19] *Cypræa tigris.* [20] *Cypræa arabica.* [21] *Cypræa isabella.* [22] *Cypræa madagascariensis.*
[23] *Trivia.* [24] *Ovulidæ.* [25] *Doliidæ.* [26] An allusion to their capacious size.

PLATE 105. SOME OF THE LARGER COMMON SEA SHELLS.

1. "Purple" Shell [Pupu] (*Purpura aperta*); so called by reason of a purple dye secured from certain species. 2. Pupu (*Purpura sp.*). 3. Hairy Triton [Pupu ole] (*Triton*

(Description of Plate Continued on the Opposite Page.)

are represented in Hawaii by two species, there being but fifteen species described. The partridge tun [27] is the more common, though a specimen is a real prize. It is fairly typical of the family. The tun is a large shell with a stout spire and swollen body-whorl that is banded by strong spiral ribs. The shell is marked with crescents and irregular lines of white on a rich brown ground color, suggesting the breast of a partridge. They are said to attain a length of fifteen inches, but the specimens found on the beach are seldom more than a third that size. The black-mouthed tun [28] is much rarer. It is dirty white in color and has the outer lip dark brown.

Cameo Shells.

The helmet or cameo shells [29] are active predatory mollusks that live along sandy shores in the warm seas. There are perhaps three dozen species and sub-species, of which five or six are known to occur in the waters about Hawaii. They all agree in being thick, heavy shells with short spires. The aperture is long and ends in a recurved channel. The typical horned helmet [30] occurs in the islands. Although it is a rare shell here, it is of more than ordinary interest since it is one of the shells used elsewhere in the manufacture of cameos, cutting a white figure on an orange-brown ground. It is the giant of the family, reaching a foot in length. The shell is yellowish-white tinged with yellowish-brown, and is studded over the back with three rows of tubercles. Blotches of dark brown occur on both the curiously expanded lips and on the knobs.

The more common form on Oahu is *Cassis vibex,* which has four short spines at the base of the lip and is seldom more than three inches in length. It is a fleshy-ash color, obscurely banded and varied with light and dark chestnut. The lip on its outer margin is marked with chocolate spots. A variety [31] also occurs that is smaller, thicker and has small elongated tubercles on the shoulder.

Moon Shells.

In the family of moon shells, or naticas,[32] the shell is more or less globular or ear-shaped and the aperture differs from that of the preceding families in

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[27] *Dolium perdix.* [28] *Dolium melanostoma.* [29] *Cassidæ.* [30] *Cassis cornuta.*
[31] *Cassis vibex erinacea.* [32] *Naticidæ.*

(Description of Plate Continued from Opposite Page.)

pilearis). 4. Quilted Triton (*Triton tuberosus*). 5. Spindle Shell (*Fusus novæ-hollandiæ*). 6. Chocolate-lined Cone (*Conus quercinus*). 7. Lettered Cone (*Conus pulicarius*). 8. Hebrew Cone (*Conus hebræus*). 9. *Conus lividus.* 10. *Conus miliaris.* 11. Auger shell sp. (*Terebra sp.*). 12. *Terebra gouldi.* 13. *Terebra oculata.* 14. *Terebra aciculina.* 15. Hermit Shell (*Cassis vibex var.*). 16. Hawaiian Top Shell (*Trochus sandwicensis*). 17. Hump-backed Cowry [Leho] (*Cypræa mauritiana*). 18. *Cypræa reticulata.* 19. Turban Shell (*Turbo chrysostomus*). 20. *Turbo intercostalis;* showing the operculum in place. 21. *Cypræa sulcidentata.* 22. Worm Shell [Pohokupele] (*Vermetus sp.*). 23. *Vermetus sp.* 24. Kaunoa (*Vermetus sp.*). 25. Partridge Tun [Puonionio] (*Dolium perdix*). 26. Umbrella Shell [Opihi kapuailio] (*Helcioniscus exaratus*). 27. Conoid Harp Shell (*Harpa conoidalis*).

that it is smooth and without canals. The outer lip is smooth and sharp. The inner lip is turned back in some species so as to conceal the umbilicus,[33] as may be plainly seen in one of the species of the genus here shown. The shells, placed in the two hundred and twenty-five or more species in the different genera, vary greatly in shape. Examples of the same species often vary through a long series of color patterns, rendering the ten or more species that occur here difficult of determination, even in the hands of specialists and when aided by a large series of shells.

The living animal is remarkable for the very large foot, which is used to crowd the creature through the sand in search of other mollusks, mostly bivalves, upon which they feed. Their habits are interesting, and as living specimens may occasionally be secured from the sand where their favorite food is abundant, they may be studied to advantage in a small aquarium partly filled with sand and stocked with other living shells.

Slipper Shells.

Perhaps the most abundant shells along the coast of our islands are the various species of slipper shells,[34] cup-and-saucer limpets,[35] the horse-hoof shells[36] and their allies, all of which are placed in the one family[37] including the various cap-shaped or limpet-like shells. They usually have a more or less spiral apex, and the interior is often provided with a septum or internal plate of variable shape.

The living animals are found adhering closely to stones and shells, and as they spend most of their lives in one spot the shell is usually irregularly shaped to fit some particular spot on rock or coral. They feed on the minute free-swimming animals that come their way. In due time they die and add their shells to those light particles of debris cast up at high tide. Representatives of four genera, including the nine or ten species usually found in the islands, are shown. From these the main characteristics for the genera may be determined.

Horse-Hoof Shells.

Of the horse-hoof shells, four species occur about Honolulu and Hilo. *Hipponyx antiquatus* has the apex posterior of the center and is rudely and closely laminated with more or less distinct radial striæ. When alive it has a hairy epidermis. *Hipponyx barbatus* is more compressed, is strongly radially striated, and has a brown hairy epidermis. *Hipponyr imbricatus* has the interior stained with chestnut.

Worm Shells and Eulimas.

Without doubt the most curious of the shell-bearing mollusks are those included in the worm shell family,[38] in which the twisted shell might be mistaken for the tube of some marine worm, as they much resemble them in that

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[33] The name given to the cavity in the central base of the shell when the columella or axis is hollow.
[34] *Crepidula*. [35] *Crucibulum*. [36] *Hipponyx*. [37] *Calyptræidæ*. [38] *Vermetidæ*.

they are similarly twisted and are attached to stones, coral and shells in much the same way. In early life they are spiral in form and crawl about as free moving animals, but later they become attached and take on various contorted shapes. While the species are not numerous, their irregular growth, sculpture and coloring render them difficult to characterize, but the general form and appearance may be made out from the figures shown. The cæcum shells [39] are also represented in the islands by one or two species. They are minute shells which, as adults, are curved cylindrical tubes that are closed at one end by a septa.

The eulimas [40] are all small, white, polished slender shells in which the spire is often curved to one side. Three genera occur here; *Eulima* is the most important. It includes fifteen of the seventeen species commonly reported from Hawaii. Some of the species belonging to the family are known to live in or upon the sea-cucumber (loli). *Eulima major* is an inch in length and is one of the larger species found in the islands.

Pyramid and Sun-Dial Shells.

The pyramid shells [41] have slender spires of many whorls. The columella lip may have one or several folds. *Pyramidella terebellum* is smooth, creamy white, with three or four narrow spiral lines on the body, and two on the spire whorl. *Pyramidella sulcata* is longitudinally streaked with pale orange-chestnut, usually forming a series of revolving dots; the columella has three plicated folds. *Pyramidella mitralis* is whitish clouded and banded with pale brown; is strongly ribbed, usually forming little knobs at the sutures.

The family *Turbonellidæ* is represented in Hawaii by four small species which resemble the species in the preceding family, except that they are usually more pronounced in their sculpturing and usually have the columella without folds.

The curious spiral sun-dial shells [42] are easily recognized by their top-like shape and angular aperture and wide and deep umbilicus. Although they resemble *Trochus* to some extent, they are never pearly in texture. Six species belonging to two genera have been recorded from Hawaii. They are seldom taken in beach specimens, but their beauty of form and color make them especially prized by professional as well as amateur collectors. *Solarium perspectivum* has the umbilical crenulations brown; in *Solarium cingulum* they are white. The genus *Torinia* differs from the foregoing in some respects, but mainly in having the spire more elevated and the edge of the whorls rounded. *Torinia variegata,* here shown, occurs occasionally on Oahu. It is reddish-brown, variously marked with white and brown, the margin of the umbilicus crenulated and the center of the umbilical wall with a crenulated mid-rib.

Violet Snails.

Shells of the three beautiful species of violet snails [43] are often found on

[39] *Cæcidæ.* [40] *Eulimidæ.* [41] *Pyramidellidæ.* [42] *Solariidæ.* [43] *Ianthinidæ.*

at the mouths of streams. The wi [59] is found only in fresh water. It is the largest species of the genus in the islands, being more than an inch in diameter. It is black in color and the shell is curiously granular over the surface. One species [60] commonly found at Waikiki is horn color, while a second species [61] from the same locality has distinct growth lines. The black epidermis is marked with numerous minute yellowish spots, sometimes scarcely visible; the outer lip of the aperture is bluish in color.

Turban Shells.

The large family of turban shells,[62] to which belong the typical turban shells,[63] the pheasant shells [64] and the star shells,[65] is represented in Hawaii by perhaps a dozen and a half species. Not more than a third of that number are liable to be collected, however. Only two species appear in the collection of beach specimens before me from the shores of Oahu. The larger one [66] is brownish or white marbled with chestnut; the smaller one is dirty white strongly tinged with green and variously marked on the body whorl with dark brown. The characteristics employed in descriptions of the species in this family are confusing, and much skill is required in order to make the identification of the species certain.

Top Shells.

Of the top shells,[67] only two of the ten or a dozen species which have been recorded from Hawaii occur in the little collection of shore shells that serves as the basis of this brief account of the common mollusks of Hawaii. Of these, the Hawaiian top shell [68] is by far the most common. It is a shallow-water species occurring at Pearl Harbor, Hilo and elsewhere about the group where slightly brackish water may be found. The second species [69] was collected only at Kahana Bay and appears to be a rare form.

Limpets.

Several species of limpet-like shells may be easily collected from the rocks between the tide-marks, or may be found cast up on the sand beaches along the shores of all the islands. While the keyhole limpets [70] are represented by one or two species, they are by no means as common as the species belonging to the old-world limpets,[71] from which they differ by having a small hole through the apex of the shell. The families and species of this sub-order of conical, cup-shaped shells are separated in the main by obscure and difficult characteristics that render them almost beyond definite determination by amateur collectors. Two species belonging to the keyhole limpets [72] are occasionally collected, especially at Hilo, and Honolulu harbor.

To the old-world limpets belong the opihi [73] of the natives. It is a favorite food with the Hawaiians, and fine specimens may often be secured alive in the

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[59] *Neritina granosa.* The native name hihiwai is applied to all the brackish and fresh water forms of *Neritina.* [60] *Neritina vespertina.* [61] *Neritina cariosa.* [62] *Turbinidæ.* [63] *Turbo.* [64] *Phasianella.* [65] *Astralium.* [66] *Turbo chrysostomus.* [67] *Trochidæ.* [68] *Trochus sandwicensis.* [69] *Trochus* sp. [70] *Fissurellidæ.* [71] *Patellidæ.* [72] *Glyphis granifera* and *Subemarginula oblonga.* [73] *Helcioniscus exaratus.*

markets. This knee-cap or umbrella shell is roughly though evenly ribbed without and pearly white within. They attain a diameter of two inches or more and are usually completely covered with a growth of sea-moss. As they are fond of the dash of the spray, they usually cling with great tenacity to the moss-grown rocks along the more exposed portion of the sea-coast. Like their relatives, they feed on algæ of various kinds, but are commonly found sticking tight to the rocks, although they are known to move about in search of food.

Experiments have been made on certain European species of limpets for the purpose of showing how difficult they are to dislodge from their resting places. It was found that it required one thousand nine hundred and eighty-four times the weight of the living animal to detach it from the rocks.

Chitons.

The chiton shells[74] are also represented in the sea-shore fauna and, like the members of the preceding family, they are found adhering firmly to the rocks. The shell is remarkable in that it is composed of several separate overlapping plates suggesting a "coat of mail," a name often applied to various species. Specimens may be taken from under stones on the shore at Pearl Harbor and about Hilo, but as there are more than two hundred and fifty living species in the world, more than one of which occurs in Hawaii, the beginner can hardly hope to definitely identify his material. Specimens are of unusual interest, however, as they are believed to be a very primitive type of mollusk and are known to occur elsewhere in very ancient geologic strata.

One of the prettiest shells to be picked up occasionally on the sea-shore in the islands is the beautifully-banded bubble shell,[75] the body whorl of which is characteristically marked by two delicate pink bands that are set off from the white ground by well-defined blackish bands. Another species,[76] with a greenish body, is often found well concealed on mossy rocks along our coasts. The thin pale-green shells are so delicate, however, that they are seldom found except living and attached to the rocks. Although related to the preceding[77] family, they are held separate from it as *Scaphandridæ*.

Sea Slugs.

The sea slugs,[78] and especially the sea hares,[79] are curious naked mollusks occasionally found cast up on the shore, entangled in the seaweed or else caught in tide-pools along the shore. The numerous species vary in size from small animals up to creatures several inches in length. They also vary in form and color to such an extent that they are not easily recognized as members of the great phylum to which the more ordinary shell-bearing animals belong.

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[74] *Chitonidæ*. [75] *Hydatina amplustre*. [76] *Smaragdinella viridis*. [77] *Bullidæ*.
[78] Order *Nudibranchiata*. [79] *Aplysiidæ*.

CHAPTER XXXVI.

PLANTS AND ANIMALS FROM THE CORAL REEFS: PART ONE.

Of the many groups of animals living on or about our tropic shores, the fishes and mollusks have received attention in other chapters. There remains for consideration some of the more common and striking of the many varied forms of plant and animal life that are sure to awaken the interest of any one who visits the shore or, better still, is so fortunate as to spend even a few hours wading in the shallow water that covers the fascinating coral reefs.

The Common Crabs.

Of the various orders of the larger animals yet to be considered, the crabs and their marine relatives are perhaps the most conspicuous and at the same time the most omnipresent. Some one of the tribe inhabits almost every rod of the sand beach and almost every loose stone along the shore furnishes a shelter for one or more of these active, interesting, curious creatures.

Nearly every child is familiar with some of the more common shore forms and perhaps can call them by their native names and tell something of their many peculiar habits. But few, indeed, even of those who are skilled in such matters, can name the rarer of the odd forms of crab-like animals that inhabit the ocean and are liable to be captured by almost anyone who will take the trouble to turn over a stone, stir up the sand and mud, or break up the masses of living and dead coral along the shore.

As the number of marine species belonging to this huge class far exceeds any other group of marine animals, we can do little more than point out the main characteristics of the class by calling attention to a few of the common forms. The body of an animal of this class is typically made up of a number of hard plates or rings variously arranged, but always forming an outer hard or thickened shell or skeleton. The skeleton plates are usually so arranged as to divide the animal into a variable number of segments. Each segment ordinarily bears paired, jointed legs or swimming organs.

The wide variation in form and plan among these creatures can be gathered from the examination of such animals as crabs, crawfish, prawns, shrimps, mantis shrimps, sand-hoppers, fish-lice, whale-lice, acorn and stalked barnacles, and a long list of less known denizens of the deep, all of which belong to this grand division of the animal kingdom of which the lobster is taken as the typical form.

The Lobster.

The so-called Hawaiian lobster,[2] the ula of the native fishermen, is the large species of marine crawfish so abundant in the Hawaiian market. Those familiar with the large pincer-clawed American lobster[3] will appreciate at once that the local species is quite a different creature. By zoölogists the

[1] *Crustacea.* [2] *Panulirus japonicus.* [3] *Homarus americanus.*

Hawaiian species is placed in a separate family and is known as the rock lobster.[4] The large size, enormously long, stout antennæ and spiny carapace of the ula, and the absence of the pincer-claw, are among its most conspicuous characteristics and serve to separate it at once from the fifteen or twenty species of crabs, lobsters, shrimps and prawns that find their way into the markets.

The ula is caught in lobster traps, or more commonly by stringing a net about the reef and leaving it during the night. As lobsters are active at night, they become entangled in the net when they come out of their hiding places among the rocks to seek food. Although they appear large and showy in the market stalls, their color is such that they harmonize perfectly with the rocks and seaweed where they make their home. They are, therefore, very difficult to detect on the reef, and are not often seen by one unfamiliar with their appearance or habits.

They feed upon both fresh and decayed fish, various invertebrate animals, and to some extent on seaweeds. The lively demand for them, owing to their excellent food qualities, brings large numbers of them fresh and sprawling into the markets every day. The ulaapapa[5] is also a large species of crawfish-like animal, quite common in the markets, that is a favorite food of the native people.

Prawns.

Prawns[6] of several species and brackish and fresh-water shrimps[7] are common in the fish stalls and are of excellent quality.

Turning to the short-tailed Crustacea, or the crabs, a dozen species at least are offered for sale. The papai, the aama, and the alamihi are the more common forms, while such crabs as the kukuma, the papa and the papai lanai are less abundant. The alamihi is a notorious scavenger on the coral reefs about Honolulu. The kumimi is regarded as poisonous by the Hawaiians. They are fairly common along the shore, and they and their close relatives are quite generally avoided by experienced crab catchers.

The common black rock-crab[8] is the species usually found hidden under stones at low tide. A similar dark-colored, but more active, species prefers the dash of the spray along rocky shores, while a pale sand-colored crab[9] lives in burrows that it makes for itself in the sandy shore just above high tide. Other forms live their lives hidden away in the coral heads; and so the list might be extended almost indefinitely, as more than three hundred species belonging to the short-tailed[10] and the long-tailed[11] Crustacea are enumerated by Miss Mary J. Rathbun in her report on this section of the Hawaiian marine and fresh-water fauna. As eighty of the species are described by her for the first time, the brief characterization of the common forms is too difficult a

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[4] *Palinuridæ.* [5] *Scyllarides squammosus.*
[6] *Aloalo*; this native name is most commonly applied to the mantis-shrimp.
[7] *Opae.* [8] *Grapsus grapsus tenuicrustatus.* [9] *Ocypode ceratopthalma.*
[10] *Macrura.* [11] *Brachyura.*

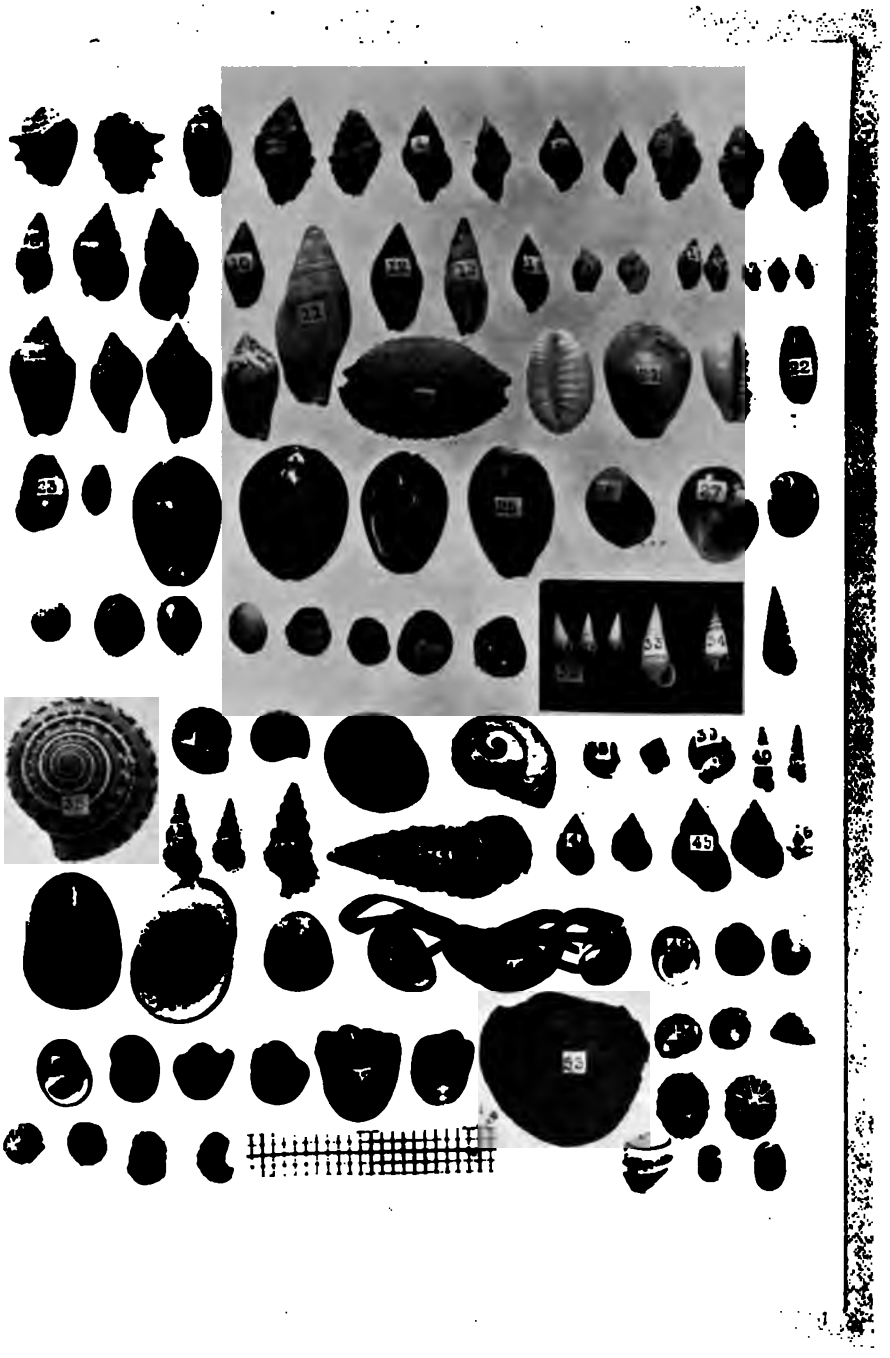

PLATE 106. SMALLER COMMON SEA SHELLS.

1. Spotted Purple Shell (*Ricinula ricinus*). 2. Banner Shell (*Vexilla vexillum*). 3. Mulberry Shell (*Sistrum morus*). 4. Kolcalea (*Peristernia chlorostoma*). 5. *Peristernia*

(Description of Plate Continued on the Opposite Page.)

task to be undertaken here. The reader is referred to the accompanying plates for the names of a number of the more common shore species.

Hermit Crabs.

Mention should be made of the species of hermit crabs[12] that occur in such abundance along our shores. They are especially interesting, since they do not have the long, hard tail of the shrimp or lobster, nor a short one that can be doubled underneath as is the case with the ordinary crabs. Instead they have a soft fleshy tail that requires to be covered and protected. Apparently aware of this defect in its organization, the hermit crab, be it large or small, old or young, invariably thrusts itself for shelter into some empty sea shell. Once established in its shell house, it is subsequently never quite ready to leave it, except to exchange its abode for a larger one when it finds its quarters too cramped for comfort, owing to its own growth; or, occasionally, for a new home that in weight and design is more closely in accord with its notion of what a domicile should be. For these reasons they may be styled the professional house-hunters along the shore. Once sheltered and protected in the empty shell of some mollusk, they become aggressive and are always on the lookout to better themselves. Occasionally one will forcibly eject the living animal or another crab from the shell it chooses.

This house-hunting process may be easily seen by placing a few hermit crabs in an aquarium together with a variety of empty shells and a liberal supply of food. With a full stomach the necessity for a larger house is soon felt. But if the process becomes too tedious to watch, the crab may be ejected by force, when, if care is taken not to injure the two or three pairs of rudimentary feet, by means of which it retains possession of its borrowed dwelling,

[12] Sub-order *Onomura*.

(Description of Plate Continued from Opposite Page.)

chlorostoma var. 6. Tankard Shell (*Cantharus sp.*). 7. *Cantharus sp.* 8. *Cantharus sp.* 9. Fish-Basket Shell (*Nassa hirta*). 10. Mitre Shell (*Mitra sp.*). 11. *Mitra sp.* 12. *Mitra sp.* 13. *Mitra sp.* 14. *Mitra tabanula.* 15. Dove shell (*Columbella turturina*). 16. Zebra Dove Shell (*Columbella zebra*). 17. Niihau Shell (*Columbella varians*). 18. Spotted Conch [Pu leholeho] (*Strombus maculatus*). 19. *Strombus maculatus; var.* 20. Madagascar Cowry [Leho puupuu] (*Cypræa madagascariensis*). 21. Money Cowry (*Cypræa moneta*). 22. Isabella Cowry (*Cypræa isabella*). 23. *Cypræa semiplota.* 24. Snake-head Cowry (*Cypræa caput-serpentis*). 25. *Cypræa carneola, var.* 26. Moon Shell (*Natica melanostoma*). 27. *Natica marochiensis.* 28. Horse-hoof Shell (*Hipponyx antiquatus*). 29. *Hipponyx barbatus.* 30. *Hipponyx imbricatus.* 31. Slipper Shell (*Crepidula aculeata*). 32. Eulima Shell (*Eulima sp.*). 33. *Eulima major.* 34. Pyramid Shell (*Pyramidella terebellum*). 35. Sun-Dial Shell [Pupu puhi] (*Solarium perspectivum*). 36. Ornament Shell (*Torinia variegata*). 37. Violet Snail (*Ianthina fragilis*). 38. *Ianthina exigua.* 39. *Ianthina globosa.* 40. Ladder Shell (*Scalaria sp.*). 41. Pupu alapii (*Scalaria lamellosa*). 42. Horn Shell (*Cerithium columna*). 43. *Cerithium obeliscus.* 44. Small Periwinkle (*Littorina pintado*). 45. Mottled Periwinkle [Kolealea] (*Littorina scabra*). 46. Measure Shell (*Modulus tectum*). 47. Sea Snail Shell [Kupee] (*Nerita polita*). 48. A wrist ornament made of Kupee shells; often worn as an emblem of mourning. 49. Little Sea Snail (*Neritina neglecta*). 50. Pipipi (*Nerita picea*). 51. *Neritina cariosa.* 52. *Neritina vespertina.* 53. Wi (*Neritina granosa*); a fresh water species. 54. Top-shell (*Trochus sp.*). 55. *Patella sp.* 56. *Patella sp.* 57. Pupu moo (*Ischnochiton sp.*). 58. Bubble-shell (*Hydatina amplustre*). 59. Little Emerald Shell (*Smaragdinella viridis*).

PLATE 107. THE REEF AT LOW TIDE.

The native fishermen have just captured a squid; in the background Koko Head, an extinct crater, is shown.

it will immediately seek shelter in the nearest shell at hand. The crab will back into its new home, inserting its tender abdomen into the shell until the aperture is plugged by its claws and the hard part of its body.

Often at low tide during the day a dozen or more of these active creatures will be found carefully hidden away under some loose stone on the reef. When disturbed they start off in all directions, each sheltered in a different species of shell and each carrying its own borrowed house on its back like a snail. Not infrequently other animals, as barnacles, oysters and sea-anemonies take up their permanent residence on the shell occupied by a hermit crab and are in this way carried about by them.

Barnacles.

There is little in the appearance of adult barnacles to suggest that they are in any way related to their crab and lobster cousins. Such is the case, nevertheless, and by zoölogists they are looked upon as furnishing an excellent example of degeneration through quiescence, for when they hatch from the egg they are free swimming animals that closely resemble the young[13] form of the crabs and shrimps, with but a single eye. Later on they have six pairs of swimming feet, a pair of compound eyes, and two well-developed antennæ, and are still free swimming animals. But when the creature makes the final change to the adult condition, it attaches itself by means of a cement-like substance to a stone, shell, pile or floating log, or to the bottom of a ship, and gives up all attempts at locomotion. It then loses its compound eyes and its feelers, and develops a protecting shell. The swimming feet become modified into grasping organs and henceforth it abandons any attempt to look and act like other Crustacea and devotes its energies to fanning such food as comes its way into its mouth, with its legs. There are two main groups of the order,[14] including the barnacles, that are liable to attract attention on the sea-shore. One family[15] includes the stalked species familiarly known as goose mussels or goose barnacles, a name derived from an ancient belief that if one fell from its support it turned into a goose. They usually occur hanging by the long stalk[16] to the bottoms of ships, to floating timber or submerged wood of any kind. The sessile barnacles,[17] acorn shells, or pioeoe as they are called by the natives, are everywhere abundant along the shore. The entire animal is enclosed in a tent-shaped shell composed originally of six pieces, which is capped by an operculum made up of four valves.

Unfortunately, the shore forms have not as yet been fully studied. A dozen species of barnacles were enumerated by my friend, Dr. Pilsbry, from the material gathered by the ship Albatross. But one of these, a species of acorn barnacle[18] belonging to the typical genus of that family, was secured in shallow water. The remainder were deep-water or off-shore forms, most of them occurring in water two or three hundred fathoms deep. Of the twelve species secured, eight proved to be undescribed. A careful study of the shore

[13] Naupiius. [14] *Cirripedia.* [15] *Lepadidæ.* [16] Peduncle. [17] *Balanidæ.* [18] *Balanus amphitrite.*

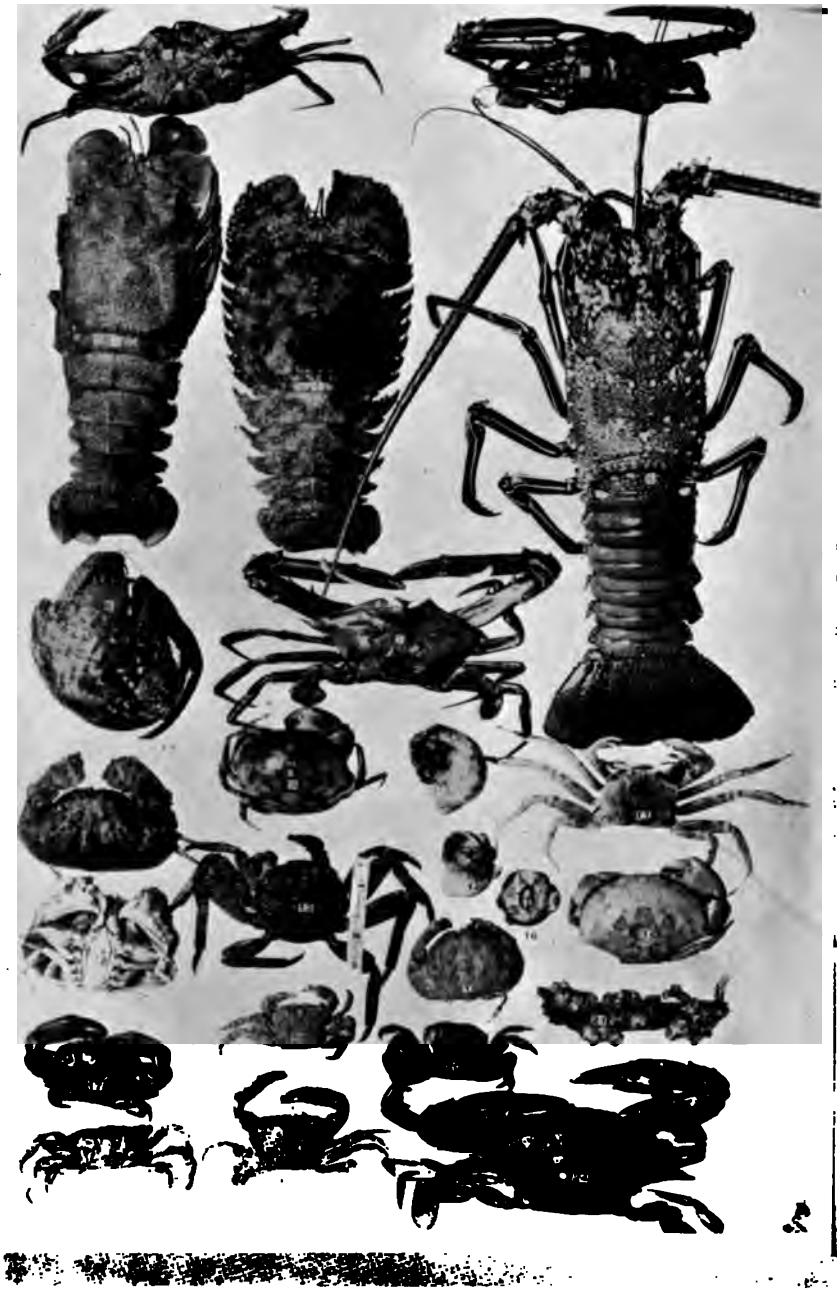

PLATE 108. COMMON CRABS AND BARNACLES OF THE CORAL REEF.

1. *Podophthalmus vigil* (female). 2. *Podophthalmus vigil* (male). 3. *Scyllarides squammosus.* 4. *Parribacus antarticus.* 5. *Panulirus japonicus.* 6. *Dardanus gemmatus.*

(Description of Plate Continued on the Opposite Page.)

fauna would doubtless add many new forms to the list of Hawaiian species. For example, a large flat white species apparently undescribed, perhaps a coronet barnacle,[19] attaches itself to the skin of the sea turtle. Moreover, there are doubtless examples of the truly parasitic species that are still more degenerate in form and habit and occur as parasites feeding on the larger crustaceans.

Common Corals.

The fragments of coral occasionally cast up on the sand beach are sufficient to awaken in everyone a desire to know more of the life and habits of the living creatures that produce the curious stony structure, and this desire has tempted many to explore for themselves the wonderful reefs for which the islands are so celebrated.

The public long ago accepted, apparently without question, the assertion of a worthy poet[20] that the coral animal was an insect, Zoölogists, however, have long known that it is not an insect, but a polyp—a very different creature, indeed—belonging to the great phylum,[21] including all such animals as hydroids, corals, sea-fans, sea-pens, jellyfish, sea-anemonies and their allies.

There are, of course, many kinds of polyps, varying through a great variety of shapes and sizes, but they all conform fairly well to a general plan of body structure, a little more complex in its organization than that of the sponge. They have a more or less typical cylindrical body, with an interior cavity connected with the outside world by a single large opening at the free end. This opening is surrounded by a circle of arm-like processes or tentacles, hence the name polyp, meaning "many-footed." The tentacles are continuations of the body wall and composed of the same tissues. The fresh-water Hydra, a minute animal less than an eighth of an inch in length,[22] is usually figured as the type of the whole great phylum. But for our purpose the common type of sea-anemonie, of which there are many species living on the rocks and along sandy shores or attached to piles and wharves, may be taken as an enlarged example of a single polyp. The chief difference between the two is that the animals known as the coral polyp usually live in enormous colonies and form skeletons of lime,[23] whereas the sea-anemonies are solitary, or at most gregarious, and secrete no hard skeleton. Both the anemonies[24] and the calcareous corals,[25] however, are included in the same class.[26] Though belonging to different orders, they seem to have the same general food habits.

[19] *Coronula* sp. [20] Alexander Montgomery. [21] *Coelenterata.*
[22] This interesting animal has not so far been reported from the fresh water pools and streams of Hawaii.
[23] Calcium carbonate. [24] *Actiniaria.* [25] *Madreporaria.* [26] *Anthozoa* or *Actinozoa.*

(Description of Plate Continued from Opposite Page.)

7. *Podophthalmus vigil* (male). 8. *Calappa hepatica* (male). 9. *Carpilius convexus.* 10. *Calcinus elegans.* 11. *Ocypode ceratophthalma.* 12. *Calappa hepatica* (female). 13. *Grapsus grapsus tenuicrustatus.* 14. *Calcinus latens.* 15. *Carpilius maculatus.* 16. *Chelonobia testudinaria.* 17. *Elisus lævimanus.* 18. *Metopograpsus messor.* 19. *Calappa hepatica.* 20. *Metopograpsus messor.* 21. *Balanus amphitrite.* 22. *Macrophthalmus telescopicus.* 23. *Thalamita integra.* 24. *Portunus sanguinolentus.*

Sea-Anemonies.

The food and general habits and life history of the sea-anemonies may be studied with profit by placing the living examples of any of the common shore forms, with the bit of rock to which they are usually attached, into an aquarium. When disturbed they contract into an almost unrecognizable mass, but when unmolested they expand into beautiful aster-shaped, flower-like, brilliantly-colored animals, so that a collection of living species is a veritable sea flower-garden. That they are not flowers, however, may be shown by attaching a small piece of meat to a thread and dropping it into the circle of petal-like tentacles. Almost instantly the long tentacles close over the food and shift it to the mouth, where the juices are extracted and the flesh digested.

As a rule, sea-anemonies settle where food is most liable to be carried to them by currents of water. Sometimes they attach themselves to other animals, as crabs, and in this way are carried about from place to place. That there are a large number of species about Hawaii is apparent to the most casual observer, but as far as the writer knows, they have never been studied and classified.

Turning now to the stony corals,[27] so important as reef builders, we find that though they are much more minute as individuals, they are more liable to develop into large colonies. Thus a single cabinet specimen of coral often represents, as a life work, the combined involuntary secretion of myriads of these patient and persistent animals. Interesting and beautiful as the bleached skeletons of the stone corals are, the living animals in their habitat on the growing reef are infinitely more fascinating to study. In the different species the expanded animals cover the skeleton with their soft bodies, giving to them a variety of colors as varied and as delicate as those in the rainbow.

The Growing Coral Reef.

Those persons who for the first time see a growing coral reef through a glass-bottomed boat, or, failing that, through a water-box with a glass bottom, are invariably lost in admiration. Though they are privileged to repeat the experience again and again, they never tire of viewing the peaceful, brilliant scene beneath the wave. There, with the living and dead coral as a background, are mingled in wild and ever-changing confusion a multitude of nature's curious plants and singular animals. All are garbed in the most wonderful, striking and varied colors imaginable, and as they swim in and out among the corals or tranquilly wave to and fro with the rise and fall of every wave, they form a veritable vision of delight that time and distance cannot dim.

To have visited Hawaii without visiting some of these tropical submarine gardens is to have missed a golden opportunity, but to live in Hawaii, often within the sound of the surf that breaks over her fringing coral reefs, and not to have first-hand knowledge of their wonders, is to be remiss indeed.

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[27] *Madreporaria.*

The coral reefs of the Pacific have been much studied by oceanographers, zoölogists and geologists who have sought to wrest from them something of the history of the formation of the islands in this vast ocean. The geologic significance of the Hawaiian reefs has been pointed out in another connection.

While but few have ever attempted to list the various species of corals found here, their study was first undertaken seriously long ago. In 1840-41 the renowned geologist James D. Dana, whose epoch-making book on the coral islands is a scientific classic, visited Hawaii and examined the reefs, as a member of the scientific staff of the United States Exploring Expedition. As a result a dozen of the more common shallow-water forms were described as new by him in a portion of the report of that expedition, published in 1846. Since then others have added to the list, but it remained for my friend, Dr. T. W. Vaughan, to give the subject the attention it deserves. As a result of his labors, based primarily on the collections secured by the Albatross expedition in 1902, but supplemented by a large collection of shallow-water coral secured by members of the staff of the Bishop Museum, we now have available for the specialist a handsome monograph in which representatives of fifteen families, including thirty-four genera, to which, according to that author, are referred one hundred and twenty-three species, varieties and forms. Of that number more than three-fifths are described and figured for the first time. Some idea of the richness of the coral fauna of any given locality can be gathered from the fact that the reef and shallow waters along the south side of Oahu, but especially at Waikiki, yielded examples of thirty-four of the species enumerated.

While a single species [28] of mushroom-like coral was brought to the surface by the dredges of the Albatross from the great depth of eleven hundred and fifty fathoms, the great majority of the forms, seventy-seven in number, occur in water from one to twenty-five fathoms in depth. Of the fourteen genera that occur in this shallow water zone throughout the group, ten were collected on reefs of Oahu from Pearl Harbor to Diamond Head. Representative specimens of the common genera from this locality are here figured. The figures will aid in the generic determination of such forms as are most liable to be collected, but definite identification of the species and the almost numberless forms of certain species is in many cases almost impossible, even when the type specimens can be seen.

The genera occurring in the shallow water about Oahu may be regarded as the living representatives of the reef-building forms that for thousands perhaps millions of years have been building the lime rock that fringes the islands.

Of the several genera *Porites*, the pohaku puna of the natives is the most abundant and is represented by the largest number of forms. The *Pocillopora* are perhaps next both in size and abundance, and like the preceding genus, they range through an extensive list of varied forms. *Montipora* is next in abun-

[28] *Bathyactes hawaiiensis.*

PLATE 109. COLLECTING ON A REEF.

1, 2, 3. Showing the use of the water-glass and collecting outfit. 4. A heart urchin (*Brissus carinatus*) with spines removed. 5. A cluster of Mytilus shells attached to each other by the curious hair-like byssus.

dance, while such genera as *Pavonia, Favia, Leptastrea* and *Cyphastrea* occur in isolated places here and there in certain favorable localities.

The mushroom coral,[29] or huahua akai, forms a remarkable group of solitary corals that are fairly common, especially in holes or reef pools on the outer edge of the reef. They take their name from their resemblance to the inverted head of an expanded mushroom. They are remarkable and beautiful objects, and make handsome souvenirs of a day's visit to a coral reef. The "sea mushroom," or in fact any of the corals, can be easily cleaned if they are placed in a bucket of fresh water before they have been out of the sea-water long enough for the animal to die and begin to dry up. Each day or so the water should be changed and the macerating animal washed out by a stream of water from the hydrant. When thoroughly cleansed the coral should be placed on a clean board in the sun to bleach.

Perhaps the most strikingly beautiful of the stalked corals is a species[30] which so far has only been found on Oahu, growing on the edge of the small coral islands in Kaneohe Bay. When alive the animal is a rich red-orange color and has the top of each short branch surrounded by a single orange-yellow polyp that when expanded is three-fourths of an inch in diameter. On the approach of danger the animal can completely withdraw within the cup in which it lives.

So far as known, the brain corals[31] have never been taken in Hawaiian waters. They, together with many other forms offered for sale in the curiosity shops of Honolulu, doubtless come from the islands of the south Pacific or from the Philippines.

The Eight-Rayed Corals.

While the Alcyonarians are seldom seen by the reef collector, it is a matter of interest to know that of the sixty-eight species of the "eight-rayed corals" taken by the Albatross on its epoch-making cruise about the islands, thirty-nine were described as new to science in Dr. C. C. Nutting's reports on the material. He states that of the three orders of *Alcyonaria* discussed in his paper, the first,[32] including the colonial forms, usually typified by the organ-pipe coral, are represented by only five species.

Sea-Pens and Sea-Fans.

The order[33] including the sea-pens and similar forms where the colonies are arranged bilaterally and symmetrically on an axial stem, have sixteen species in the off-shore fauna. The sea-fans, sea-plumes and their allies form the most abundant order.[34] Like the other orders of the class, they all have eight-rayed polyps. The beautiful horny tree or bush-like growth to be seen in museums, however, gives but little idea of the appearance of the living animal. Forty-eight species are included in the list of Hawaiian species, but

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[29] *Fungiidæ.* [30] *Dendrophillia manni.* [31] *Meandrina.* [32] *Alcyonaceæ.* [33] *Pennatulacea.* [34] *Gorgonacea.*

they so very seldom reach the sea-shore that their presence in the islands would be unknown but for the work of such expeditions as that of the Albatross.

JELLYFISH.

Those who have been boating on the beautiful Pearl Harbor lochs are almost sure to have seen large numbers of the curious swimming-bells of the jellyfish[35] floating gracefully about through the water. If one is captured it will sting the hands like a nettle. For this reason the pololia, as it is known to the Hawaiian fishermen, is let severely alone by those who have once experienced the stinging, itching sensation, which is the result of a poison injected by myriads of little stinging cells. These stinging cells or lasso cells are common to many forms of Cœlenterata, and are very effective in protecting these apparently helpless animals from their enemies. Other species of large jellyfish are occasionally seen as they slowly swim at the surface of the ocean, or are rarely found stranded on the shore by the receding tide, but not more than a half dozen species all told are known from the islands.

HYDROIDS.

The *Hydromedusæ* resemble the members of the foregoing family, differing mainly in being smaller in size, and in the fact that the medusæ or heads found floating at the surface, in most cases, are in reality budded off from small animals,[36] which form colonies and are permanently fixed at the bottom of the sea. The young medusæ after leaving the hydroids or stems, begin an independent free-swimming career. In the course of growth they pass through a series of stages and finally become sexually adult. The eggs of the female medusa do not, as a rule, develop into medusæ, but into hydroids, so that there is an alteration of generations. As the hydroids seldom grow in water more than a few hundred fathoms deep, the medusæ are usually found in shallow water offshore, though there are pelagic forms that are exceptions to the rule. Only a few species of the free-swimming forms have so far been reported from Hawaii. The common form,[37] a new species, is a very small bell-shaped animal with from twelve to fourteen lash-like tentacles suspended from the edge of the bell.

Dr. Nutting visited the Hawaiian Islands on the cruise of the Albatross, and subsequently devoted much time to a study of the hydroids collected about the islands. He found the fauna very rich, varied and interesting, but as the material examined was that secured in water from ten to five hundred fathoms deep, the littoral fauna is yet to be studied. His list enumerates forty-nine species, twenty-nine of them proving new. As the species are placed in twenty-seven genera belonging to eleven families, the great variation in the forms will be apparent. The shore species are often called moss animals,[38] since many of them are pretty feathery, plume-like creatures, so closely re-

[35] *Scyphomedusæ*. [36] *Zoophytes* or *Hydroids*. [37] *Solmaris insculpta*.
[38] This name is more properly applied to the *Polyzoa*.

sembling sea-mosses that it is with difficulty that the untrained observer is convinced that they are really animal colonies. Some of the genera[39] are well-known animals and occasionally figured in general reference books. The Hawaiian species in every case are rarer forms that can only be recognized by experts when aided by elaborate descriptions.

In this connection mention should be made of certain colonial hydroids[40] that secret masses of carbonate of lime out of which the animal protrudes like a coral polyp. They are usually pink or orange-colored, and are often called corals. Several species are found very plentifully on our coral reefs. On close examination it will be seen that they differ in structure from the true corals. The solid-looking masses with lobed processes, or bosses, are the most common,[41] though fine branching examples[42] also occur. In both families the whole surface can be seen, with the aid of a lens, to be covered with small pore-like openings. If a vertical section is examined, indistinct layers can be seen running parallel with the outer surface. Only the surface is alive, the inner mass being composed of the dead skeletons. Thus these animals secrete lime and build up a coral-like skeleton in much the same way as do the true corals, which are polyp colonies and quite different in their organization, though secreting similar masses of lime.

Zoölogists often cite this peculiar fact as an example of "convergence," meaning thereby that two animals of different types have become adapted to similar conditions of life and come to superficially resemble each other. Other animals, as whales and fishes, birds and bats, show similar evidence of convergence. Indeed, it has not been uncommon for naturalists to place totally different animals in the same group on account of their resemblance. The Hawaiian *Hydrocorallinæ* have not been fully studied as yet, and there appears to be no list of even the common species.

The Portuguese Man-of-War.

Sea-bathers occasionally make the acquaintance of the Portuguese man-of-war,[43] which is perhaps the best known member of a third family[44] of the jellyfish tribe. It floats, by means of an air sack, on the surface of the sea. Its stinging power is tremendous, producing a maddening, scalding pain which lasts for hours. As the stinging tentacles are long and thread-like and float out loosely in the water, the beautiful "blue bottles" are things that can be more safely admired at a considerable distance. On the windward shore of all the islands they are often stranded by thousands by the ebbing tide, where they dry down to a mere bubble in a few hours.

Sea Money.

Another common form[45] is a flat coin-shaped disk with fine radiating white lines. About the edge are innumerable fine tentacles. The animal,

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[39] *Sertularia, Campanularia* and *Plumularia*. [40] *Hydrocorallinæ*. [41] *Milleporidæ*.
[42] *Stylasteridæ*. [43] *Physalia utriculua*. [44] *Siphonophoræ*. [45] *Porpita pacifica*.

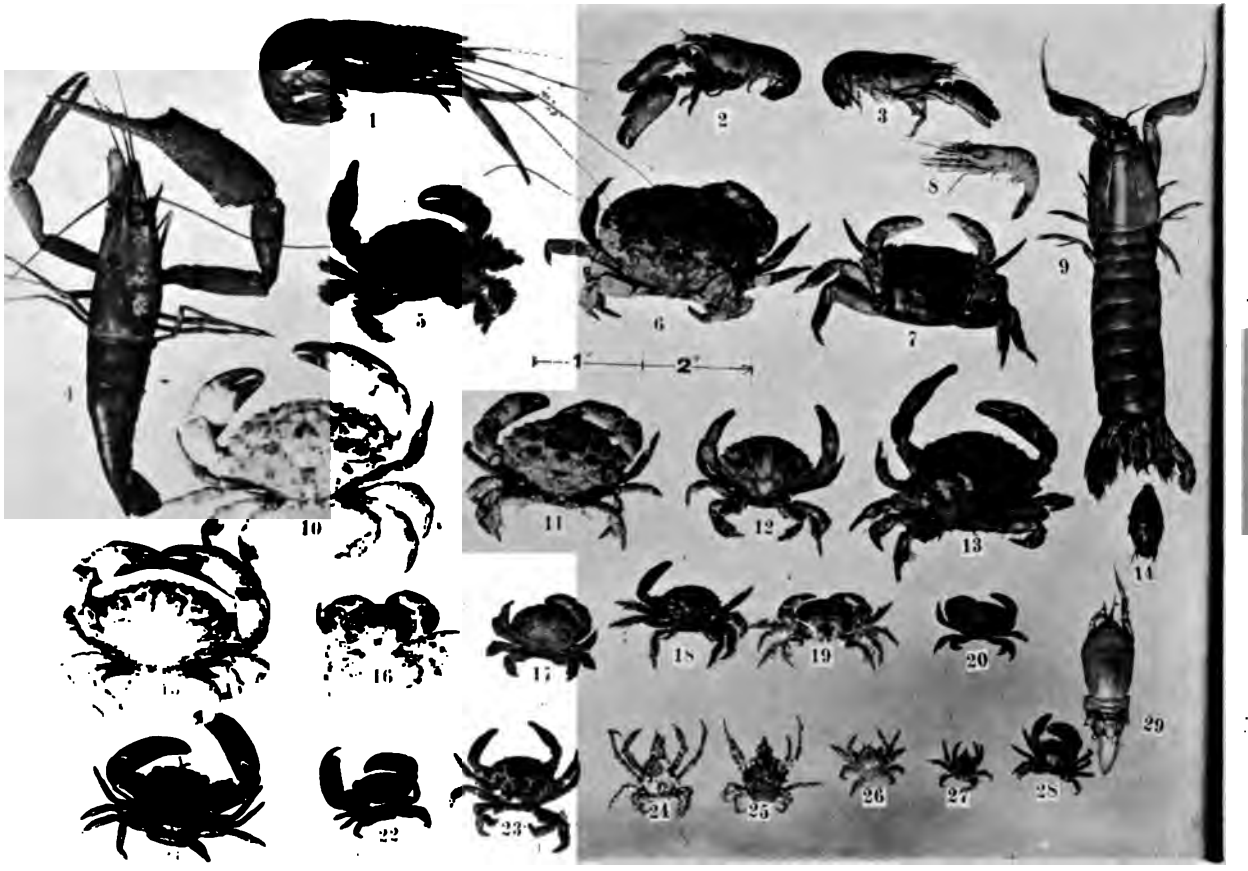

PLATE 110. SMALL CRABS AND CRAB-LIKE ANIMALS FROM THE REEF.

(For Description of Plate See Opposite Page.)

tentacles and all, is less than two inches in diameter and is a beautiful blue color. When stranded the soft parts soon disappear, leaving a white disk about the size of a dime, which is often appropriately called "sea money." There is also another form[46] that is fairly common at times. It somewhat resembles the Portuguese man-of-war in that it is surface-swimming and bears on its upper surface an oblique sail. It differs from the man-of-war most noticeably in having short rather than long pendant tentacles.

A curious transparent balloon-shaped little animal[47] with two long retractile tentacles, with odd tag-like appendages attached, has also been taken in Hawaiian waters. It belongs to a fourth family,[48] which also includes an odd transparent, many-ribbed cylinder-shaped animal,[49] four or five inches in length, one end of which is rounded, the other truncated and occupied entirely by the immense mouth. As these animals are jelly-like, they seldom, almost never, reach the shore. For that reason they are rare curiosities when once they are secured. It is a matter of interest to know, however, that as many as twenty species of jellyfish or medusæ-like animals have been reported by Dr. A. G. Mayer as occurring in the collections made by the Albatross.

Moss-Animals.

Mention has been made of the sea-mats or moss-animals.[50] They are usually found attached to stones, forming an incrustation which, upon examination, seems to be made up of very minute cells each perforated by a small pore. Besides the encrusting forms there are branching forms that resemble hydroids, but unfortunately our fauna has not yet been studied, so that the species are not known.

Allied to the Polyzoa, and by most authors placed in the same phylum,[51] are the very rare, but very interesting, lamp shells[52] or arm-footed animals. The shells of these animals are so like the common clam shells in general form that they were once classed as a division of the mollusks, but they may be distinguished from them by the fact that their valves are unequal in size, and that they are attached by a small stalk which passes out through a hole in the apex of the larger valve. While it is to be presumed that species occur offshore, the only examples[58] that have come under the writer's immediate observation were a few delicately-colored specimens a half inch in diameter, secured in a small collection of shells brought up in dredging operations in Honolulu harbor, and

[46] *Vellela pacifica.* [47] *Hormiphora fusiformia.* [48] *Ctenophoræ.* [49] *Boroe* sp. [50] *Polyzoa.*
[51] *Molluscoidea.* [52] *Brachiopods.* [58] *Terebratula sanguinea.*

Description of Plate.

1. *Macrobrachium grandimanus* (immature). 2 and 3. *Crangon* = (*Alpheus*) *lœvis.* 4. *Macrobrachium grandemanus* (mature). 5. *Actæa affinis.* 6. *Platypodia eydouxii.* 7. *Metopograpsus messor.* 8. *Palæmon pacificus.* 9. *Pseudosquilla ciliata.* 10, 11, 12. *Leptodius sanguineus.* 13. *Etisus lævimanus.* 14. *Nerocila australasiæ.* 15. *Leptodius sanguineus.* 16. *Lophozozymus dodone.* 17. *Actæa speciosa.* 18. *Phymodius nitidus.* 19. *Xanthias canaliculatus.* 20. *Carpilodes Monticulosus.* 21. *Trapezia cymodoce intermedia.* 22. *Trapezia digitalis.* 23. *Rhymodius ungulatus.* 24, 25. *Simocarcinus simplex.* 26, 27. *Perinea tumida.* 28. *Domecia hispida.* 29. *Hippa adactyla.*

a few shells of apparently the same species, gathered on Laysan Island. They are of more than ordinary interest, since they represent a group which was very abundant in early geologic times and of which a few type-forms have persisted, almost unchanged, to the present day.

Sea-Squirts.

The sea-squirts or ascidians form a class [53] that is well represented on the reef and the sea-bottom offshore. To look at the shapeless sack-like mass of a leathery or gelatinous texture having two openings through which, in the living creature, currents of water enter and leave the body, no one would for a moment believe that they could claim even a remote relationship with the typical vertebrate animals. Nevertheless, they are placed by modern zoölogists in a phylum [54] with several other unusual animals thought to form a group [55] more closely allied to the typical vertebrates than to any of the many varied types of invertebrate animals. In order to trace the affinities, however, the larval condition of the sea-squirt must be studied, as they are strangely degenerated animals in the adult form. They begin life as a free-swimming tadpole-like larvæ which approaches somewhat to the vertebrate type of structure. That is, they possess a notochord,[56] a central nervous system, gill slits, and certain other fundamental characteristics. As they attain the adult condition, however, radical changes in form and structure take place. They usually find a suitable location and become attached, remaining for their life-time in one place, firmly adhering to various objects, as a shell, a coral, a rock, or a bit of seaweed. The pelagic free-swimming sea-squirts or salpa I have never seen in Hawaii, but there are both simple and compound ascidians in abundance about the islands. Among the compound fixed types, the colonies, as they are called, are produced by budding from a single parent animal. They commonly form jelly-like incrustations in which a whitish star-like pattern can be seen. They abound on the under side of submerged objects, or on seaweeds. But the simple forms, being much larger, are sure to attract the notice of the naturalist on the reef. On being lifted from the water, attached to a stone or coral, they squirt a small stream of water from the openings as they contract.

The Balanoglossus.

A curious soft-bodied worm-like animal,[57] whose claim to a place among the *Chordata* rests upon the fact that an outgrowth of the intestine extends into the probosis, where it forms a solid rod which, in its origin, suggests the notochord in more typical forms, occurs in the sand in shallow water along our shores; in pockets in the reefs, as, for example, in the reef at Kahala, Oahu. Specimens may be secured by passing the sand through a sieve, or dredging it

[53] *Tunicata.* [54] *Chordata.* [55] *Protovertebrata.*
[56] A dorsal longitudinal rod of supporting cells that corresponds to the primitive backbone.
[57] *Balanoglossus.*

up on the tines of a rake. They are much sought by zoölogists owing to their primitive chordate characters, but uninformed collectors would place them at once among the worms. If specimens are carefully collected and placed in a jar of sea water and sand, they make interesting exhibits in the schoolroom or laboratory.

CHAPTER XXXVII.

PLANTS AND ANIMALS FROM THE CORAL REEF: PART TWO.

The Hawaiian reefs abound in representatives of the phylum,[1] including such odd and diverse animals as the starfish, sea-urchins, brittle-stars and the sea-cucumbers. The curious bleached white skeletons of the sea-urchins, with the beautiful lace-like pattern pierced in fine holes over the biscuit-shaped shell or test, are among the objects picked up with shells and seaweed on the sand beach. They are hardly to be recognized, however, as the remains of the spiny sea-urchin so often stepped on by incautious bathers. They are the "hedge-hogs" of the sea, since the numerous calcareous plates forming the shell are covered in the several species with variously-shaped spines. These spines serve the ina, as the sea-urchins are called by the natives, as a means of protection, and in certain species they are used to assist in boring the burrows often inhabited by them in the solid rock below low-tide.

Sea-Urchins.

The common forms are a black species,[2] or ina eleele, and a whitish form,[3] ina keokeo. They both are very plentiful on the coral reefs about Honolulu and are gathered and eaten by the natives. If one is taken alive from its hiding place beneath the loose stones on the outer edge of the reef and examined, the spines will be found to move on a ball-and-socket joint. The tubercles on the test forming the attachment for the spines are arranged mainly in five broad bands extending from the top round to the bottom or oral side. Alternating with these are five narrow bands bearing fewer tubercles, but pierced by the small holes arranged in rows as referred to above. Through these holes pass numerous curious tube-feet, each provided with a sucker on the end. These are therefore the walking bands.[4] The vent is situated in the summit or aboral side of the test. The membrane on the bottom or flat side surrounds the mouth, from which protrude the tips of five pointed teeth. If the membrane is removed a curious conical structure will be seen commonly called Aristotle's lantern.

One of these animals dropped into a salt-water aquarium will prove an interesting object. Placed in water, the tube walking feet expand and the creature will slowly glide along, or if placed on its back it will right itself.

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[1] *Echinodermata.* [2] *Echinometra* sp. [3] *Echinometra* sp. [4] Ambulacral zones.

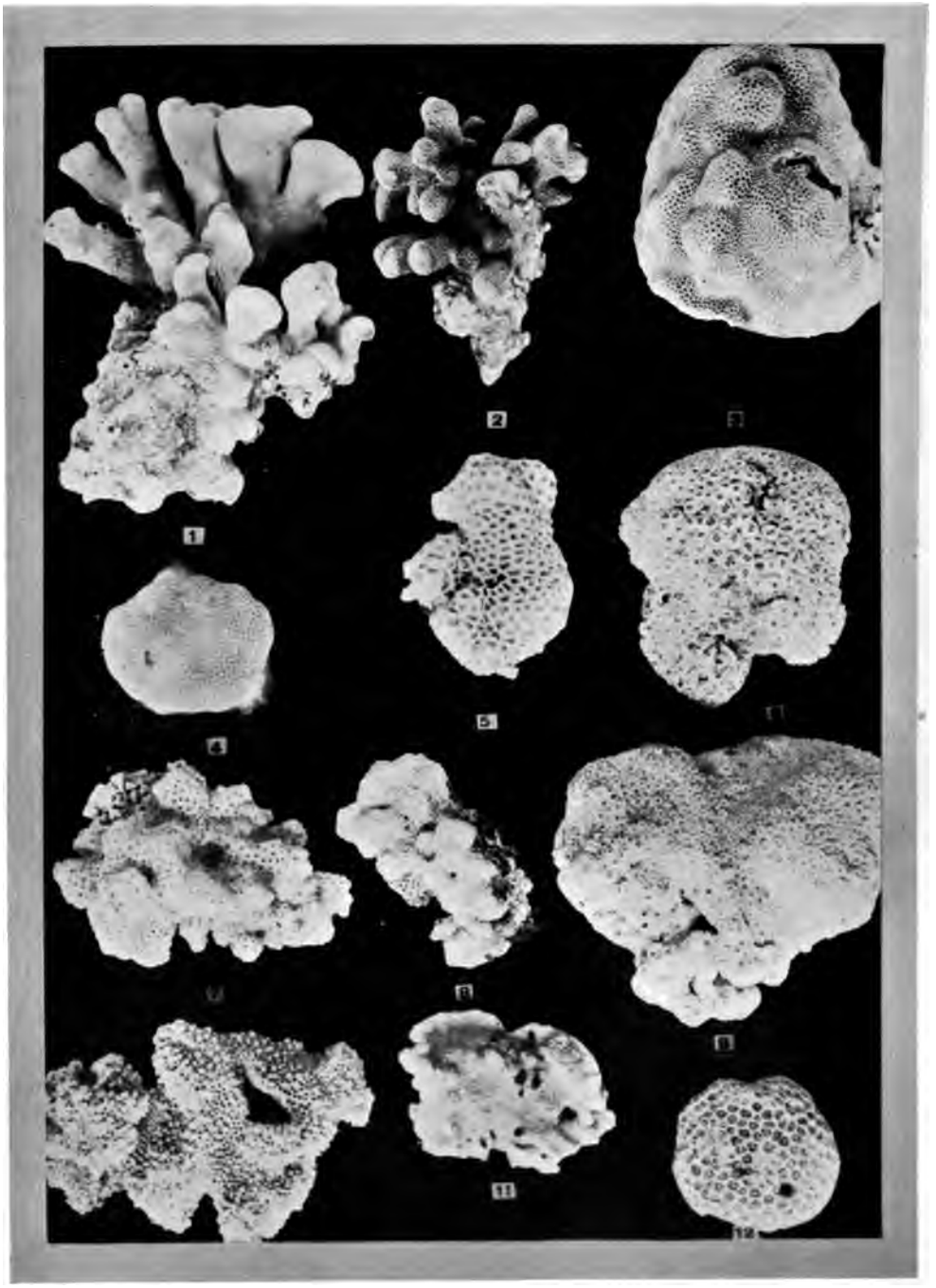

PLATE 111. COMMON CORALS AND CORAL ROCK.

1, 2, 3, 4. [Akoakoa—the general name of coral]. *Porites spp.* and varieties; the species are variable in form and a large number of forms have been enumerated. 5. *Coelastrea tenuis.* 6. *Leptastrea sp.* 7. *Cyphastrea ocillina.* 8. *Leptastrea hawaiiensis.* 9. *Leptastrea agaassizi.* 10, 11. *Montipora spp.* 12. *Coelastrea sp.*

They are said to feed on seaweed and also on dead fish and decaying matter of various kinds. The large purple-black species,[5] with long, slender, awl-shaped spines, prefers the deeper water in the holes toward the outer edge of the reef. With it occurs a similar species [6] in which the long spines are banded gray and black. Both species are known as Wana, or sea eggs, and are much sought for by the Hawaiians, who are very fond of them.

The spines of the wana are both sharp and brittle and inflict a serious wound. If the native fisherman is so unfortunate as to be injured by one he will bite the wound savagely in order to grind the spine into fine fragments so that the pieces will come out later on with the pus.

The beautiful club-spined [7] urchins are quite common at certain places on the reef, and are often on exhibition in the Aquarium in Honolulu. They are as large as the preceding species, but are a reddish-brown color, and the spines are heavy and blunt and imperfectly triangular.

A curious rough rock urchin,[8] the haukeuke, has the spines short and blunt over the back, but long and dull-pointed about the edge. They are fond of the rough sea and adhere to the black lava rocks exposed to the full dash of the waves.

A large heart-shaped urchin,[9] covered with fine short brown hair-like spines, is known as the sea biscuit or heart-urchin. Other forms are occasionally collected in shallow water, but the majority of the Echinoidea are found in deeper water offshore. The number of species inhabiting the Hawaiian waters is not determined, but it is known to be a rich fauna, there being a number of rare species.

Starfishes.

While the true starfishes [10] are fairly common in the deeper water offshore, they are not very abundant on the coral reef. As a matter of fact, it is a great find to collect a specimen of any size from the reefs about Oahu. It is necessary to understand at this point that in the typical starfish the arms are usually, though not always, five in number and that, as a rule, they are not sharply marked off from the central disk, as is the case with the brittle-starfish,[11] two or three species of which are plentiful in shallow water. In the true stars the feet are located in a definite groove, while in the brittle stars the grooves are not present.

The connection of the feet with the water-vascular system is very interesting. On the back between two of the arms may be seen a curiously roughened plate [12] that in reality is a sieve through which the water is strained before it enters the system. Connected with this sieve-like body is the stone-canal. It runs downward and connects with the ringed-canal which encircles the mouth; from this canal five radial canals, one for each arm, pass outward just above the ambulacral grooves. The radial-canals give off side branches

[5] *Diadema pauciapinum.* [6] *Echinothrix desori.* [7] *Heterocentrotes* sp. [8] *Podophora pedifera.*
[9] *Brissus carinatus.* [10] *Asterioidea.* [11] *Ophiuroidea.* [12] Madreporite.

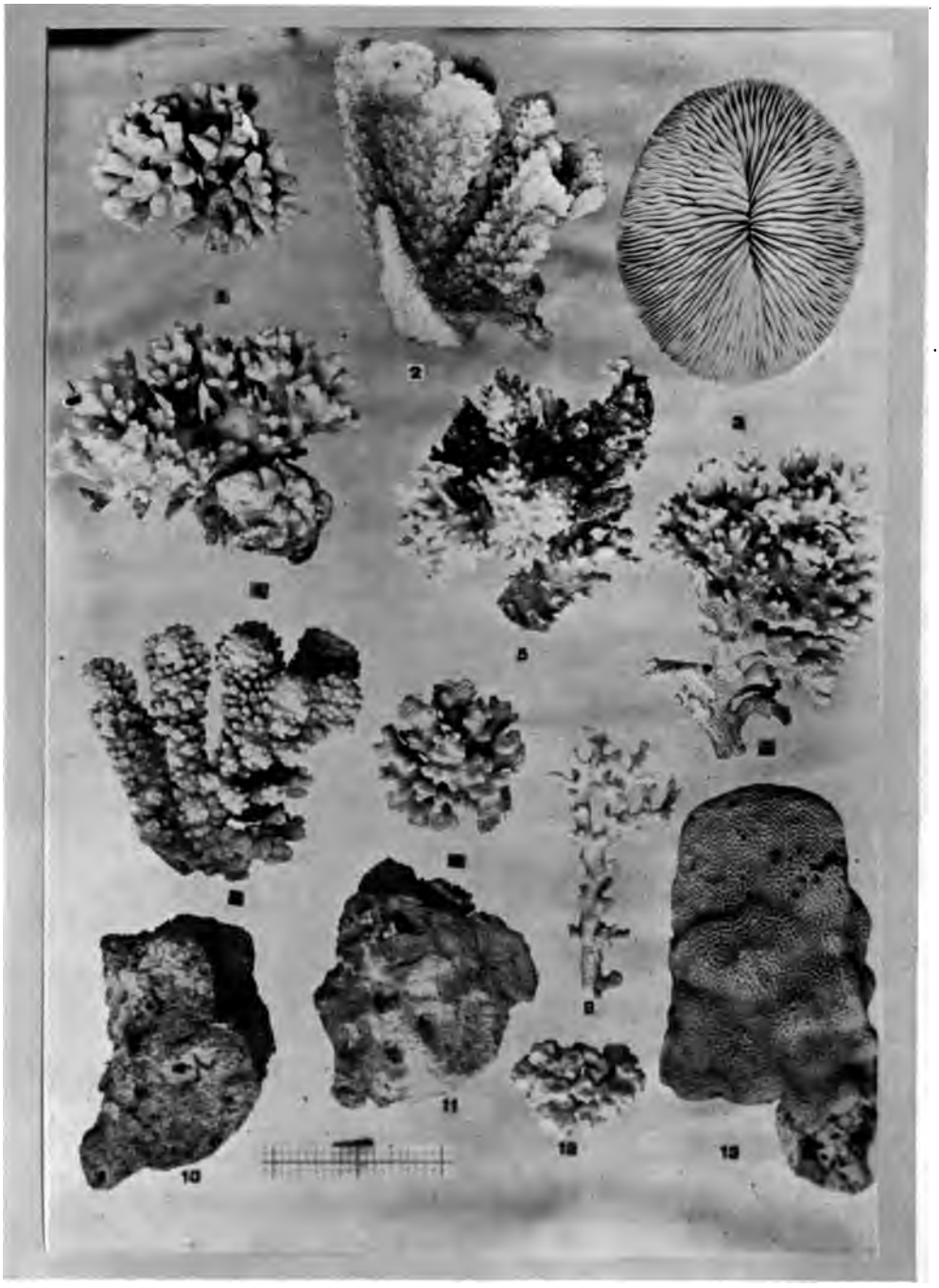

PLATE 112. CORALS AND REEF ROCK.

1. *Stepanaria sp.* 2. *Pocillipora sp.* 3. *Fungia sp.* 4, 5, 6, 7, 8, 9. *Pocillipora spp.* and forms. 10, 11. Dead coral rock showing worm holes and other marks of disintegration. 12. *Stepanaria sp.;* beach worn specimen. 13. *Porites sp.*

to connect with the bulb-like sacks[13] that in turn connect with the tube-feet. Sea water is forced into this system of tubes and by the expansion or contraction of the little sacks, the feet are thus extended or withdrawn.

The favorite food of the starfishes is said to consist of the common bivalves, but it is asserted that there is no animal that it can catch that it will not devour. On the oyster beds, especially along the Atlantic coast, they are very destructive. They wrap themselves about the oyster and in so doing literally turn the stomach inside out through the mouth. In a little while the bivalve is forced to relax its muscles and allow the shell to open. The edge of the stomach is then inserted between the valves of the shell and the soft parts of its prey are thus digested outside the starfish's body. The habits of our Hawaiian species have not as yet been studied, though it would not be a difficult matter to do so.

Large specimens of an eight-rayed starfish[14] are occasionally captured at Pearl Harbor. They are often a foot and a half in diameter, are cream-colored above, mottled with burnt sienna and chocolate, and are white below. A similar but very small species is to be found abundantly in the coarse green sponges in Kalihi bay and at Pearl Harbor. A small, stiff, irregularly-developed pink leather-like species,[15] without spines, is occasionally found crowded into small holes in the coral reef. It is remarkable for its powers of reproducing new and complete animals from the broken fragments of the old one; a single specimen in the laboratory has been made to produce a dozen or more complete animals from the fragments broken from the parent, while the parent disk has gone on and reproduced all the lost parts.

A curious five-sided form, ten inches or more in diameter, has also been taken in the shallow water in Pearl Harbor, but of recent years the dredging operations have apparently driven the large species away. My friend Dr. Walter K. Fisher was on the great Albatross expedition and has described fifty-two of the sixty species taken on that cruise as new to science. They are placed in twenty families and are distributed into no fewer than forty-six genera. As can be imagined, the collection represents a most astonishing variety of starfish forms. But as the collection was made in water from ten to a thousand fathoms down, his splendidly-illustrated monograph is an index to what is in the great deep offshore, rather than a guide to the forms liable to be gathered by hand by the wading naturalist.

The Brittle-Starfish.

The brittle-stars[16] have long serpent-like arms attached to a relatively small and usually rounded disk-shaped body. They differ from the true stars in a number of ways. It is important to note that the digestive system does not extend into the arms, but is confined in the central body, and that they have no grooves on the under side of the arms, such as exist in the typical starfish. The arms are long and very flexible and are used almost entirely as the organs of locomotion.

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[13] Ampullæ. [14] *Luidia hystrix.* [15] *Linckia* sp. [16] *Ophiuroidea.*

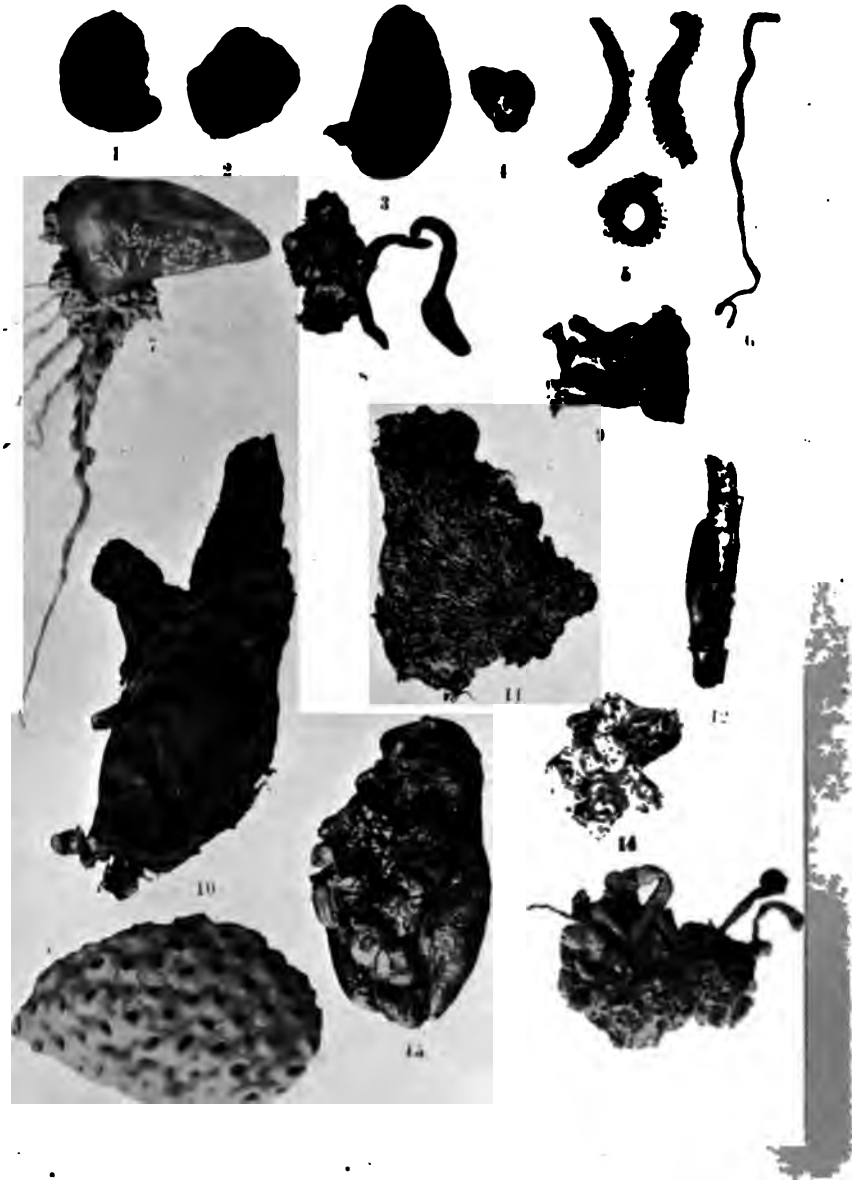

PLATE 113. MISCELLANEOUS MARINE ANIMALS.

1, 2, 3, 4. Common Tunicates. 5. Marine worm [Koe] from the coral rock. 6. Flat-worm. 7. Portuguese Man-of-war [Pololia] (*Physalia utricula*). 8. Marine worm (*Gephy-*

(*Description of Plate Continued on the Opposite Page.*)

The common blue-black brittle-star,[17] known to the Hawaiians as pea, is sure to give the unsuspecting person a start as it scrambles out of some hole in a dead block of coral lifted from the water and held in the hands for closer inspection. Like the true starfish, the brittle-stars are inclined to be gregarious. Often a dozen or two will be gathered under a single head of coral, or a stone half buried in sand in a hole in the coral reef. As they go scurrying off in all directions they look so weird and snake-like that one instinctively shrinks from taking them up in the hand, though they are known to be perfectly harmless.

They can be kept for a short time in an aquarium, where their habits can be studied to advantage. Their food, however, is difficult to provide, since it consists of marine organisms and decaying organic matter lying on the mud and sand on the sea bottom. It is scooped into the mouth by special tube-feet, two pairs for each arm. The stomach is a simple sac that cannot be pushed out of the mouth. A small pink species[18] with remarkably long, slender arms, with short bristle-like spines, is occasionally found in holes in coral rock, but is exceedingly difficult to secure, owing to the arms being very easily broken.

The term "brittle-star" is derived from the habit of these animals of breaking off their arms on the slightest provocation. By so doing they can readily escape from their enemies. The loss of two or three arms is of no serious consequence, since new arms are speedily regenerated. The new growth, however, may be easily recognized, as it seldom is as large as the portion it replaces. This remarkable power of regenerating lost members is a common one in the animal kingdom, worms, crabs, lizards and the like furnishing interesting examples.

Zoölogists include the basket-stars,[19] with branching arms, in the same class with the brittle-stars, but they have never been taken by naturalists on the Hawaiian reefs.

Sea-Cucumbers.

Every Hawaiian child is familiar with the loli, and most of them can tell at a glance the species that are used as food and those that are to be left lying on the reef or unmolested in the holes in the coral rock where they commonly seek attachment or shelter. They are known to Europeans by various names, as sea-cucumbers, trepang or bêche-de-mer, but whatever the name, whether they are fresh from the sea or dead, or for sale in the markets, they are the same repulsive, uninteresting-looking objects.

They are all included by zoölogists in one class[20] of sausage-shaped,

[17] *Phioema* sp. [18] *Ophiothrix* sp. [19] *Cladiophiuræ*. [20] *Holothuroidea*.

(Description of Plate Continued from Opposite Page.)

rea) from the dead coral. 9. A *Coelenterate* (sp. indet.) from Honolulu harbor. 10. Sea-squirt (*Tunicate*). 11. Marine worm from a piling in Honolulu harbor. 12. Portion of the tube of a ship worm (*Teredo*) in a piece of timber. 13. Hue. 14. Sea-anemonie. 15. Sea-squirt. 16. Sea-anemonie.

PLATE 114. COMMON MARINE PLANTS AT WAIKIKI.

leathery marine animals with the mouth at one end of the body, which is sometimes surrounded with tentacles which may be expanded or withdrawn. They appear to bear but little resemblance to their cousins, the sea-urchins, or their second cousins, the starfish, but if one is closely examined it will be found to resemble the sea urchins in certain fundamental features, especially in possessing a ringed canal about the mouth which gives off tubes that run up and backward to supply water to the tube-feet when they are present. While they are far from being star shaped and are without the long, sharp spines of the typical sea-urchins, they appear to trace their ancestry back to a generalized starfish-like animal, and for that reason they are all included in the one great phylum.[21]

An energetic collector may secure a half dozen species on a single expedition on the reef at low tide, but if one turns to Dr. Fisher's very comprehensive paper based on the Albatross collection, the list of Hawaiian species will be found to be a much more extensive one.

Of the forty-four species of sea-cucumbers enumerated by this careful naturalist, nineteen are described for the first time. The fauna is placed in four families, including twenty-one genera in all. Perhaps a dozen species are liable to be gathered from the tide pools on the reef, but as they are difficult to describe in popular terms, they are even more difficult to identify. A few forms, however, may be recognized by their popular names or simple descriptions.

To all of these animals the Hawaiians applied the class name loli, but several species were recognized by definite specific names, such as loli kai, which grows about six inches long and is eaten raw or cooked; loli pua, the large black species often fifteen inches in length, which was also eaten, and loli koko, which is red inside and was not eaten by the natives.

The names thus applied by the Hawaiians are fairly accurate and constant throughout the group. As the definite detection of the characters which separate the species in most cases can only be made out by the examination of the calcareous deposits in the skin of the animal, their classification is a far too difficult problem for the average collector. But to collect specimens of many of the species is an easy task, since they are sluggish, inactive creatures which lie buried in the sand or seek shelter underneath stones or in the crevices in the coral reef. The large, dark-brown, blackish species with ambulacral feet scattered all over the body,[22] commonly found in lava rock pools, is perhaps as well known as any of the group owing to its size when adult. A reddish, heliotrope-purple or brownish-purple species [23] frequently found in company with the large black one just mentioned, and a brown or reddish-brown species [24] of large size with a whitish ventral surface, are also common in shallow water. A well-known species [25] on the Honolulu reef is about three inches long and variously colored, the tentacles being straw color, the

[21] *Echinodermata.* [22] *Holothuria atra.* [23] *Holothuria cinerascens.* [24] *Holothuria vagabunda.*
[25] *Holothuria pardalis.*

PLATE 115. COMMON HAWAIIAN SPONGES [UPI].

dorsal surface brownish straw color, varied with lighter, the ventral surface lighter than the back. The species may or may not have two rows of dorsal spots.

A curious and striking worm-like sea-cucumber[26] is common at Pearl Harbor, Kaneohe Bay, and at other points in similar places in the shallow water on sandy and coral bottoms. Large specimens are two or three feet in length and an inch and a half in diameter. They vary greatly in coloration, but are usually reddish-orange spotted with brown, the brown forming mottlings and irregular bands. They have fifteen or more greenish tentacles an inch or more in length. These animals may be seen by the hundreds in favorable localities at certain seasons, as they slowly creep about in the algæ on the bottom, in shallow quiet water. On being lifted to the surface they completely collapse, as the water which fills the entire animal runs out, leaving only the thin contracted bladder-like skin.

Another very common variegated olive-brown species,[27] varied with whitish circles and blotches over the back, takes little care to conceal itself during the day and is quite plentiful, usually in lava rock pools. A fair-sized, dark-greenish species[28] mottled with dark brownish-green is also quite common, especially in the large tide pools on the outer edge of the reef near Honolulu.

The food of most sea-cucumbers consists of minute particles of organic matter extracted from the sand and mud, taken into the alimentary canal. The species mentioned above as common in Pearl Harbor may be seen in the process of feeding. The plume-like tentacles round the mouth are stretched to their full length. When they have gathered sufficient food particles from the water they are alternately curved round and drawn over the mouth and the food-charged water forced into the central mouth opening.

The tube-feet, when present, are the organs of locomotion; by them the animal is pulled along on its ventral surface. Several of the species, but especially the loli koko, have a disgusting habit, when disturbed, of exuding a mass of long white sticky fibers that adhere tenaciously to any object, and in which the enemies of the animals are entangled. These threads are part of the respiratory apparatus known as the gill tree, but the threads themselves are termed Cuvierian organs. When the loli becomes excessively irritated it contracts the muscles of the body wall to such an extent that the thin wall of the intestine is ruptured and a portion of the long, coiled intestine is pushed out. The animal is only temporarily inconvenienced by this experience, however, as in a short time, after a brief period of quiescence, nature refurnishes it with an entire new set of digestive organs.

Crinoids.

While the beautiful and rare sea-lilies or Crinoids are never found on the reef, it is a matter of general interest to know that they belong in the great

[26] *Opheodesoma spectabiles.* [27] *Actinophyga mauritiana.* [28] *Stichopus tropicalis.*

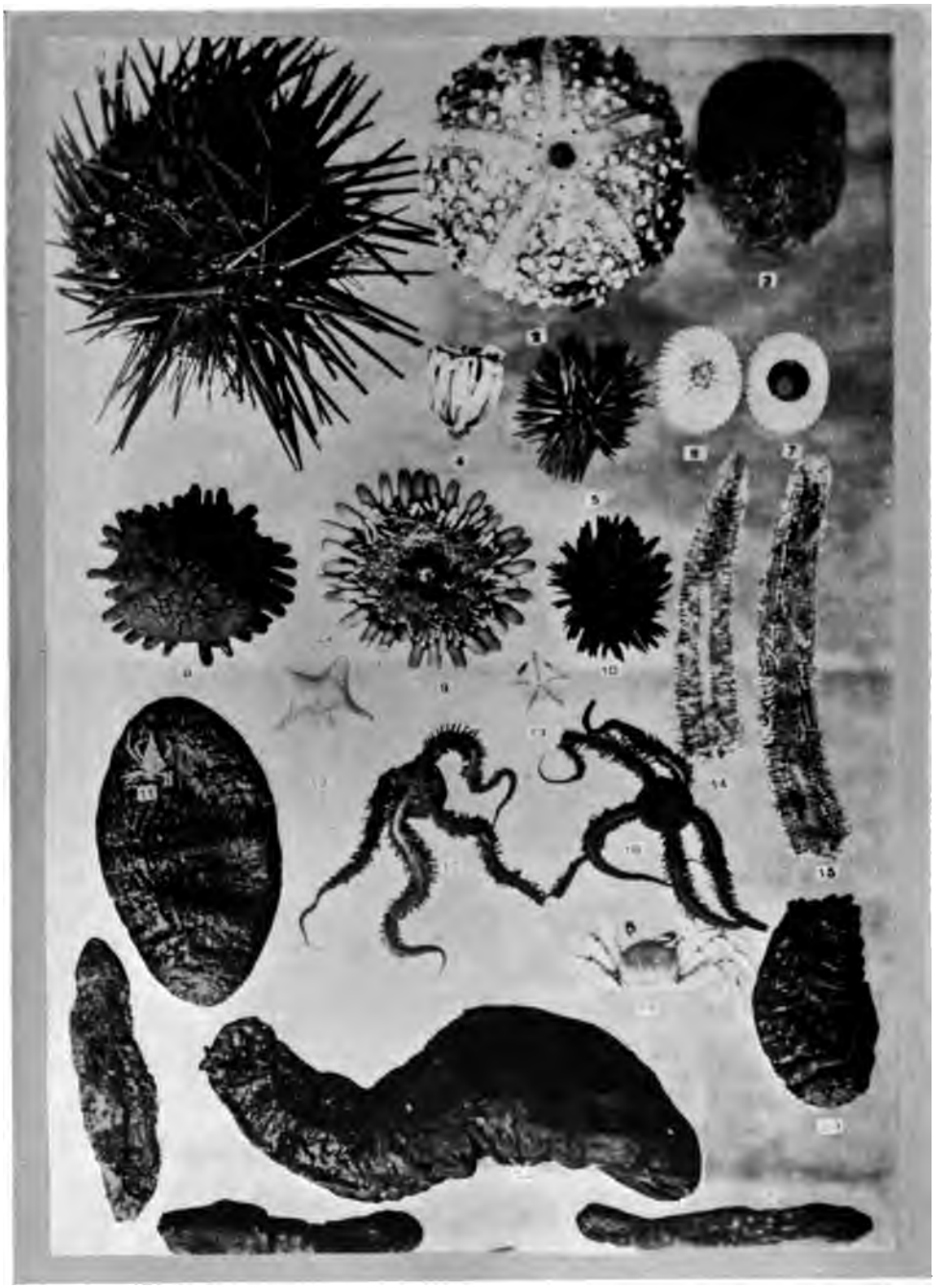

PLATE 116. STARFISH, SEA-URCHINS AND SEA-CUCUMBERS.

1. Sea Egg or Sea-urchin [Wana]. 2. The same with the spines removed. 3. Sea-beaver or Heart-urchin. 4. Aristotle's lantern: the masticating organ of a sea-urchin. 5.

(Description of Plate Continued on the Opposite Page.)

phylum including the starfish, sea-urchins and sea-cucumbers. A dozen species of this class [29] of animals, often known as feather-stars, or when fossilized as stone-lilies, were collected by the Albatross. They were placed in eight genera assigned to four families of the non-stalked forms. In the hands of Dr. A. H. Clark, the American authority on the crinoids, they all proved to be species heretofore unknown. Although it is thought that the collection secured represents only a small portion of the entire crinoid fauna of the islands, it should be remembered that all of the species were collected from water more than a hundred fathoms deep. The lower range of their distribution about the group, for want of fuller knowledge, is placed at about the one-thousand-fathom line. Although the species are peculiar to Hawaii, they all belong to wide-ranging genera.

Sea-Worms.

The great group of worm-like creatures is at best not an especially attractive one to collectors of animals, and the general naturalist is very liable to pass them by without much attention. Yet there is such a variety of marine forms that make their home on or in the living and dead coral, and in the sand and mud along the shore, that they are at least worthy of passing notice.

Of the various groups of flat-worms, a division [30] collectively termed Planarians is well represented. As they are very curious in form, being broad and flat, they are usually sufficiently out of the ordinary to attract attention when seen gliding from the under side of some object picked up on the reef. Many of them are brilliantly colored and have an easy, graceful gliding motion, enabling them to move smoothly over the surface of shells, seaweeds or stones.

The Nemertinea have a superficial resemblance to the flat-worms. They may be recognized by their soft, extensile bodies and their long thread-like proboscis, an organ which can be completely withdrawn within the animal. They are often conspicuously colored and of varying form; some are fragile, others are very slender and of great length.

By far the most important group on the reef, however, is that which includes the bristle-worms [31] and their allies, all members of the phylum,[32] including the common earthworm, the leeches and similar forms. They can be placed in the phylum without much difficulty by the fact that the body is divided into numerous similar parts called segments.

They occur in various places, some living in canals in the dead coral rock,

[29] *Crinoidea.* [30] *Turbellaria.* [31] *Polychæta.* [32] *Annelida.*

(Description of Plate Continued from Opposite Page.)

Ina keokeo (*Echinometra sp.*). 6. Aboral view of the shell or test of *Echinometra*. 7. Oral view of the same. 8. Rough Rock Urchin [Haukeuke] (*Podophora pedifera*). 9. Oral view of the same. 10. Ina liilii (*Echinometra sp.*). 11. Crab (*Simocarcinus* sp.). 12. Starfish (not Hawaiian). 13. Oral view of the same. 14. Arm of a Starfish [Pea] (*Luidia hystrix*). 15. Same as No. 14. 16. Sea-cucumber [Loli]. 17, 18. Brittle Starfish (*Phioema sp.*). 19. Sand Crab (*Ocypode ceratophthalma*). 20, 21, 22, 23, 24. Sea-cucumbers [Loli].

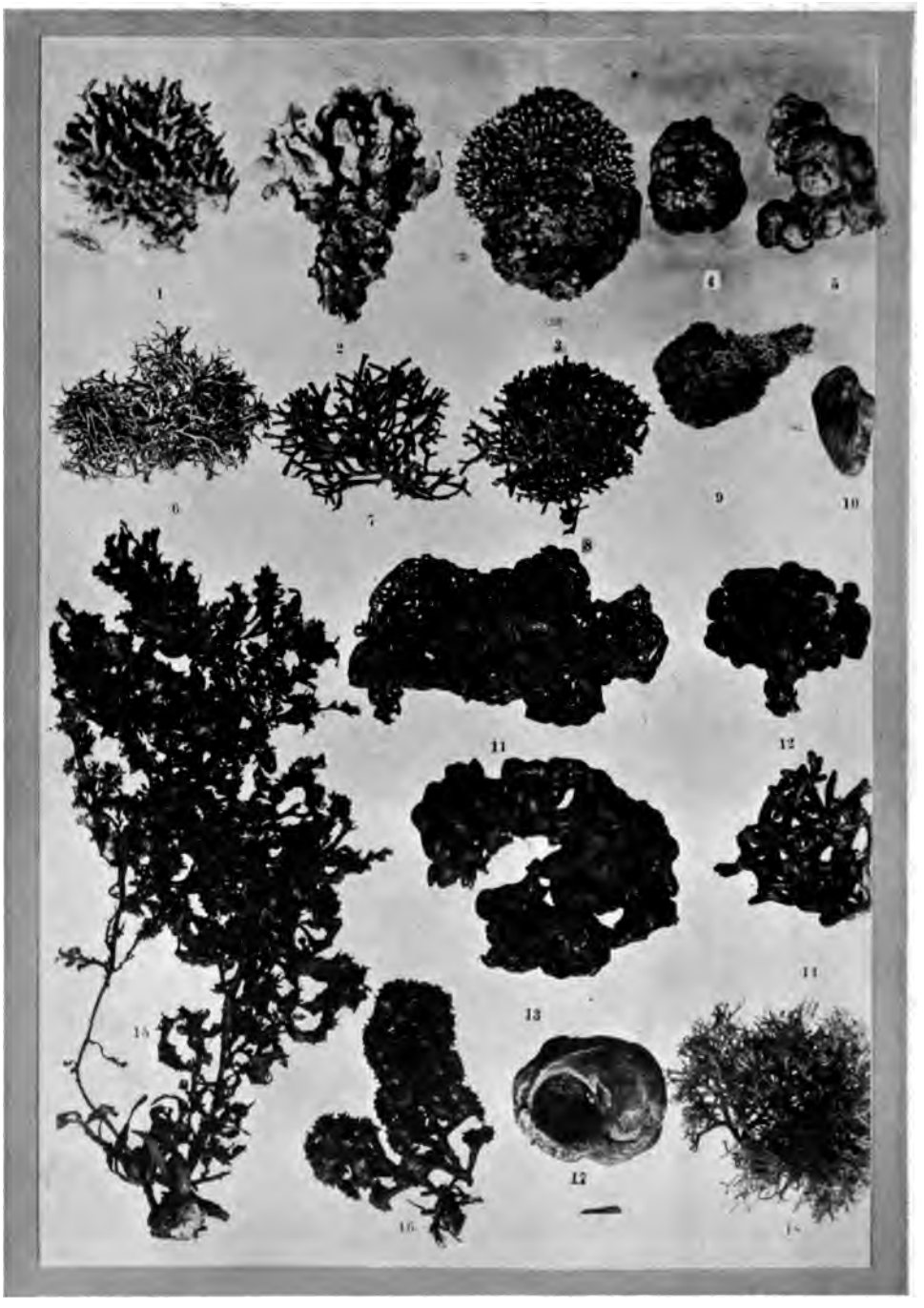

PLATE 117. MARINE PLANTS AND PLANT-LIKE ANIMALS.

some forming tubes for their habitations, while still others are noted for making paper-like tubes. Some species burrow beneath the sand and mud; others fasten their tubes to stones or coral and cover them with sand or bits of shell.

Another group of worm-like animals[33] may easily be found by breaking up old coral rocks in which they are able to drill round holes. In the common forms[34] the anterior part of the body can be drawn into the posterior part. They are tough and leathery, blunt at the tail, and taper gradually to the end of the proboscis.

Sponges.

It is a matter of regret that the many species of sponges[35] that occur on our reefs and to moderate depth in the water about them have never been systematically collected and studied. This need not prevent one from admiring and examining them, however, not only on their own account, but on account of the large number of worms, crustacea, starfish and other animals that enter them for protection.

There is scarcely a stone of any size on the reef that is without one or more of these curious creatures attached to it. Red, black, white, yellow and purple sponges are common, but almost every color one can suggest is represented. Many of them are shapeless encrusting masses; still others have a definite form, so familiar as to render their identification complete at a glance. Still others look more like weird plants than animals, and it is not strange they are often mistaken for such, when we consider their irregular plant-like growth. Although they were once claimed by botanists as part of the plant kingdom, they are now generally regarded as representatives of the simplest form of the many types of many-celled animals[36] as distinguished from the single-celled animals,[37] which are nearly all microscopic.

Sponges are free swimming animals for only a very short time, at an early stage of their development. They soon become attached to some object, and not infrequently modify their form so as to conform with the shape of the object to which they adhere. For this reason they seem to have no fixed shape of body, as individuals of the same species vary greatly.

The sponge is a very simply-organized animal and lives a very simple life indeed. Their food is the minute organisms in the water. Currents are created in the animal by means of minute flagella which wave to and fro in the tiny tubes that lead into the animal through small pores scattered over its body surface. The food is digested out of the water before it is allowed to pass out again through the large holes[38] distributed over the animal at irregular intervals. Sponges are of considerable interest to zoölogists, as they are the lowest types in which cells are found differentiated for certain purposes, as skeleton cells, reproductive cells, and so on.

Sponge culture has never been attempted in Hawaii, though the subject has been occasionally discussed. While none of the species now growing on

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[33] *Gephyrea.* [34] *Sipunculoidea.* [35] *Porifera.* [36] *Metazoa.* [37] *Protozoa.* [38] Oscelum.

the reefs have any great commercial value, it is not improbable that the fine soft species of commerce, suited to our climate and conditions, could be introduced and grown here.

Anyone who sees the living sponge will realize that the familiar bath sponge is only the bleached skeleton of the animal from which all of the soft part has been macerated and washed away, leaving only a substance known as spongin—a substance very like silk in its composition.

The division of the sponges is made not on color or shape nor habits, but on the differences in their skeletons. Two principal classes are recognized: one where the skeleton is composed of limy spicules [39]; the other class includes species with glassy [41] spicules or with horny [42] fibers. To the non-calcarious class belong the majority of the larger sponges on the Hawaiian reefs.

Seaweed.

It is a very natural transition in this connection to pass from the curious sponge animals, that so often resemble plants, to the consideration of the flora of the coral reef, since these curious marine representatives of the vegetable and animal kingdoms occur together, often in the most intimate relation, about our shores. In fact, many of the species of seaweed are attached to various species of sponges, and even more frequently sponges will be found growing on the larger forms of algæ.

The examination of the heaps of curious bright-green, brown, purple or red plants cast ashore by the sea, particularly after a heavy storm, gives to the beach ramble a charm in any quarter of the globe, but in Hawaii, with its hundreds of miles of ever-varying coast line, the gathering of the sea-mosses holds out allurements to the lover of the beautiful in nature that few can long resist.

How to Collect Hawaiian Algæ.

To gather and preserve these bright-colored flowerless plants is so easy and so fascinating a task that tourists who visit the islands, as well as old and young people who call Hawaii home, can find no more pleasant diversion than making a collection of the more common forms.

The first step in reef collecting of any kind is to find out the time each day when the tide will be low and arrange to be on the reef two or three hours before extreme low water, so that the tide may be followed out. However, algæ hunting, as well as reef collecting generally, may be greatly facilitated if the collector can have the use of a boat, a fine-toothed long-handled rake and a water box with a glass bottom. Still more ambitious collectors will want to use a dredge, though dredging about a coral reef is very difficult work. Those who are not able to dredge or wade, will find the sea-coast at high tide furnishes specimens of most of the species to be gathered first-hand farther out.

The collector will want a light canvas bag, or wicker basket, and a small

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[39] Calcarea. [40] Non-calcaria. [41] Silicious. [42] Spongin.

assortment of bottles and containers of odd sizes. A good quantity of old newspapers will also be useful. A lens, a stout knife, a pair of forceps, and a wading costume that protects the arms and legs from the sun are very important parts of the field equipment, but nothing is more necessary than a pair of stout shoes to protect the feet when wading over the rocks on the rough coral reef.

The Hawaiian tides are so uniform and slow that there is no danger to be feared from their sudden return, so the collector can work in safety and at his leisure, always taking time to gather the finest specimens to be found in the given locality. A little practice with the lens will enable the beginner to discover the fruiting bodies on the different algæ. If they ever attempt the task of naming their specimens, the importance of having perfect specimens will be appreciated; still, an imperfect example is not to be despised, since it will be of value in giving a clue to the nature of the flora of a given locality.

The specimens may be roughly dried in a shady place or salted down, or, better still, mounted and pressed while they are fresh. To do this the plants should be carefully washed and sorted in sea water, as they retain their colors better than when washed in fresh water.

The next step is to "float out" the specimen in fresh or salt water on a piece of substantial, tough, unglazed paper of the proper size. Several methods of "floating out" the specimens may be employed. A good way is to take a shallow dish or enameled pan and lay in the bottom a square piece of galvanized iron that is a trifle smaller than the pan. If the corners of this mounting table are turned down so as to make legs a quarter to a half inch long, the apparatus will work much better.

Place the floating table in the pan and cover it with water and lay upon it a piece of mounting paper that has been moistened on both sides. The specimen to be mounted is then laid on the paper and held in place with the left hand, while with the right hand, needle points and tweezers are used to smooth the branches of the specimen out on the paper. The specimen, mounting table and all, is then gently lifted out of the water and the card laid to one side to drain. When the paper is fairly dry, the specimen and its mounting sheet is placed on a sheet of blotting paper, a piece of thin muslin cloth, free from starch, spread over it and a second dryer laid over the cloth. The specimens are piled up in this way, one on top of the other, until the lot is finished, when they are placed between two flat boards, to which a little weight is added, and left to dry thoroughly. Specimens that do not adhere to the mounting sheet may be fastened in place with narrow strips of gummed paper.

The collector will soon learn that algæ, like land plants, favor certain localities, and moreover that they have their special seasons of growth. So that to gather all of the attached or fixed algæ [43] in a given locality will require many expeditions over the same locality at different seasons. It is not improbable that almost every collecting ground would yield as many as fifty

[43] For there are many microscopical species that are free swimming plants.

species, and there are some of the more favorable localities in the islands where with close and persistent work a more extended list can be secured.

It is impossible to give in a few pages a systematic survey of so extensive a group as the Hawaiian algæ. A few of the more common forms found at Waikiki are figured. These will serve to show how curious and interesting these plants are. But as not a few of the species to be gathered about the islands are as yet unnamed, the collector who is not a botanist may feel sure that he can render good service to science, and at the same time afford himself a pleasant recreation by making a carefully collected and well-labeled collection from almost any locality. The label should note such facts as the season, depth, character of the bottom, whether in brackish or salt water, exposed to tide-rush or surf or in quiet pools, and other observations of interest.

While Hawaiian algæ have been studied to some extent for years, and several important collections have been made, no one, so far as the writer knows, has ever given more than a guess at the probable extent of the flora of the Hawaiian reefs. The literature begins with a list published more than thirty years ago by Mr. J. E. Chamberlain, which gave the names of one hundred and twelve species of marine algæ common in Hawaii. In 1900 Miss J. E. Tilden spent some months in Hawaii collecting the fresh-water and marine algæ, and subsequently published a list of one hundred species in Thrum's Annual. But as the list published was only a small part of "the several hundred species collected," many of which were not described, it is to be hoped that this authority will be induced to make a more exhaustive review of the material.

Miss Minnie Reed has also made extensive collections of the algæ of the islands in connection with her especially interesting investigation of the economic seaweeds of Hawaii and their food value—for limu, as the fresh and salt-water algæ are called by the natives, has always had an important place in the native bill-of-fare. As many as seventy-five species of edible algæ were known to the Hawaiians by name. As this list of edible species is referred by botanists to thirty-eight genera, some idea of the variety of forms of the useful species can be gathered.

Almost every day at low tide native women and children may be seen on the reef gathering the daily supply; and at least a dozen species are offered for sale in the markets, along with other Hawaiian delicacies, the favorite species being limu kohu,[44] limu eleele,[45] limu oolu[46] and limu lipeepee.[47]

Seaweed has also had an important place among the native medicinal plants. But Europeans, as a rule, seldom regard this product of the sea as a marketable or an edible commodity. Nevertheless, thousands of dollars' worth of Hawaiian limu is consumed by the natives, and even a greater quantity is imported by the Oriental population.

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[44] *Asparagopsis sanfordiana.* [45] *Entiromorpha* spp. [46] *Chondria tenuissima.* [47] *Laurencia* spp.

In addition to the long list of marine species there is an extended list of fresh-water limu, many species of which were also used for food by the natives living at some distance from the sea.

But important as limu is as a food for man, its importance as a food for the myriads of animals of the coral reef that feed on it exclusively, or at one stage or another of their existence, is far greater. It is perhaps in this indirect way that it has its most significant bearing on the food supply in Hawaii, and it is the œcological relation of these curious plants and animals to their environment, that is of such absorbing interest to the student of natural history.

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The author takes this final opportunity to again express his indebtedness to those who have preceded him, and through their published works, made this popular synoptical view of nature in Hawaii possible.

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A

Abrus precatorius Linn., 207
Abudefduf sordidus (Forskal), 349
Acacia dealbata Link., 247
decurrens Willd., 247
Farnesiana Willd., **54**, 198, 205
Koa Gray., **52**, 194, **56**, 202, 211
Koaia Hbd., 226
Acanthocybium solandri (Cuv. & Val.), 349
Acanthuridæ, 372
Acanthurus unicornis (Forskal), 349, 372
Acarina, 400
Achitinella, 433, 434, 437
Achatinella (Achatinellastrum) plumata Gul. = **Achatinella fulgens, 103**, 448, 434
(Apex) lorata Fer., **103**, 448
(Apex) mustelina Migh., **100**, 432
buddii Newc., 434
cæsia Gul., 434
multizonata Baldw., 435
plumata Gul. = **Achatinella fulgens Newc.**, 434
Achatinellastrum (*see* Achatinella)
Achatinellastrum plumata Gul., **103**, 448
varia Gulick, **100**, 432
Achatinellidæ, 119, 121, 123, 433, 434, 437, 438
Achatinellinæ, 123, 434
Achras Sapota Linn., 266
Acridiodea, 429
Acridotheres tristis (Linn.), 306
Acrocephalus familiaris Roths., 314
Actæa affinis (Dana), **110**, 482
speciosa (Dana), **110**, 482
Actiniaria, 475
Actinophyga mauritiana (Quoy & Gaim.), 495
Actinozoa, 475
Aculeata, 412
Adenanthera pavonina Linn., 203
Adiantum capillus-Veneris Linn., 223
Adoretus tenuimaculatus Waterh., **99**, 406, 394, 417
Ægosoma reflexum Karsch., **99**, 406, 388
Æstrelata sandwichensis Ridgw., 309, 312
hypoleuca Salv., **78**, 310, **80**, 323, 312
Agriolimax bevenoti Collin, 439
Agrion, 424
Agave Americana Linn., 280
Mexicana var. sisalana Lam., 280
Agrion pacificum Lachl., 424
xanthomelas Selys., 424
Agromyza sp., 383
Agrotis crinigera (Butl.), **98**, 398, 396
dislocata (Walk.), 396
ypsilon Rott., 396, 422
Alauda arvensis Linn., 307
Albula vulpes (Linn.), **87**, 344, 349, 354
Albulidæ, 354
Alcyonaceæ, 479
Alcyonaria, 479
Alectis ciliaris (Bloch), **92**, 366, 349
Aleurites Moluccana Wild., **56**, 202, 210, 239
Aleyrodidæ, 427
Algæ, **28**, 116, 500
Allamanda cathartica Linn., 248
Alocasia macrorrhiza Schott, 225
Alopias vulpes (Gmel.), **86**, 340
Alphitonia excelsa Reiss., 215
Alticus, 353
Alticus marmoratus (Bennett), **94**, 374
Alyxia oliviformis Gaud.=**Gynopogon oliviformis (Gaud.), 59**, 214, 216, 221
Amarantus spinosus Linn., **53**, 196
Amastra, 433, 434, 437
frosti Ancey, **103**, 448
rubricunda Baldw., **103**, 448
textilis Fer., **103**, 448
turritella Fer., **103**, 448
violaceæ var wailauensis Pils., **103**, 448
Amastridæ, 434
Amastrinæ, 123, 434
Ameriurus nebulosus (Le Sueur), 377
Amorbia emigratella Busck., **98**, 398
Amphipoda, 409
Anampses cuvier Quoy & Gaim., **92**, 366, 349
sp., 359
Ananas sativus Schult.=Ananassa sativa Lindl. **69**, 258, 261
Ananassa (*see* Ananas)

Anas laysanensis Roths., 318
wyvilliana Scl., **80**, 323, 328, 335
Anatidæ, 309
Anax, 425
junius Drury, **97**, 392, 424
strenuus Hagen, 424
Anchovia purpurea (Fowler), **87**, 344, 349, 351
Ancylus sharpi Sykes, 438
Andropogon (*see also* Heteropogon)
Andropogon (Heteropogon) contortus Linn., **51**, 192, 209
Sorghum Brot., 285
Anisolabis annulipes Luc., **98**, 398
littorea White, 428
pacifica Erichs., 428
Annelida, **28**, 116, 497
Anobiidæ, 418
Anobium paniceum Linn., 418
Anomia nobilis Gray, **104**, 456, 445
Anomura, 471
Anona, 266
Cherimolia Linn., 266
muricata Linn., 266
reticulata Linn., 266
squamosa Linn., 266
Anosia erippus Cram., 421
Anous stolidus (Linn.), **78**, 310, 311
Antennariidæ, 355
Antennaris leprosus (Eydoux & Souleyet), **94**, 374
Anthicidæ, 418
Anthomyia sp., **99**, 406
Anthozoa, 475
Anthrenus scrophulariæ (Linn.), 395
Anthribidæ, 418
Antigonon leptopus Hook. & Arn., **68**, 250, 248
Apex (*see* Achatinella)
Aphidæ, 389, 415, 427
Aphis bambusæ Fullaway, 390
gossypii Glover, 390
maidis Fitch, 389
sacchari=**Loxerates sacchari (Zehntner)**, 389
Apis mellifica Linn.,**99**, 406, 404, 415
Aplysiidæ, 467
Apocynaceæ, 252
Apodes, 355, 361
Aprion virescens Cuv. & Val., **91**, 362, 349, 371
Apsilus (*see also* Roosvelti)
Apsilus microdon (Steindachner), 349, 371
Asplenium nidus Linn., **50**, 191
Arachis hypogæa Linn., 285
Arachnida, 409
Araceæ, 249
Aræcesus fasciculatus (De Geer), 395
Aralia Guilfoylei Cong. & March., 253
Aramigus fulleri Horn, **99**, 406, 394
Araneida, 409
Araucaria excelsa R. Br., 237
imbricata Pav., 237
Arca candida Gmel., **104**, 456, 444
sp., **104**, 456, 444
Arcea catheeu Linn., 236
Arcidæ, 444
Arctocorisa blackburni White, **101**, **436**, **426**
Arenaria interpres (Linn.), **78**, 310, 324
Arenga saccharifera Labill., 237
Argemone Mexicana Linn., **54**, 198
Argiope avara Thor., 410
Argyroxiphium Sandwicense D. C., **57**. **206**, 229
virescens Hbd., 229
Armsia, 434
Arthropoda, 400, 405
Artocarpus incisa Linn., **69**, 258, **70**, **264**, 239
Asclepias Curassavica Linn., **58**, 212
Asimina triloba Dunl., 262
Asio accipitrinus sandvicensis (Blox.), **336**
Asiracidæ, 427
Asparagopsis sanfordiana Harv., 501
Aspidium, **50**, 191
aculeatum Sw.=**Polystichum aculeatum**, 227
sp., **63**, 228
Aspidiotus hederæ (Vall.), 391
lataniæ Green = Aspidiotus **transparens** Green, 391
persearum Ckll., 391
Asplenium, **50**, 191
contiguum Kaulf., **63**, 228
erectum Bory., **63**, 228
nidus Linn., **66**, 240, 223, 253
pseudofalcatum Hbd., **63**, 228
sp., **63**, 228
Trichomanes Linn., 227
Asterolecanium miliaris = A. **pustulans** (Cock.), 391
Astelia veratroides Gaud., **57**, 206, **62**, 224
Asteroidea, 487
Asterolecanium pustulans (Cock.), 391
Astralium, 466
Athlennes hians (Cuv. & Val.), **88**, 350, 364
Atractomorpha crenaticeps Bl., **97**, 392, 429
Attidæ, 409
Aulacaspis pentagona Trag., 391
rosæ (Bouche), 391
Aulostomus valentini (Bleeker), **88**, 350, 375
Auriculella, 433
sp., **103**, 448
Avicula margaritifera Lam., 444
Aviculinæ, 444
Awaous genivittatus (Cuv. & Val.), 374, **357**
spp., 357
stamineus (Eydoux & Souleyet), 357

B

Bacilus pestes Kitasato, 401
Balæna mysticetus Linn., 301
spp., 301
Balanidæ, 473
Balanoglossus, 484
Balanus amphitrite Darwin, **108**, 474, 473
Baldwiniana, 434
Balistes, 373, 375

Balistapus aculeatus (Linn.), 349
rectangulus (Bloch & Schneider), **93**, 370, 375
Balistidæ, 373
Bathyactes hawaiiensis Vaughan, 477
Batis maritima Linn., **51**, 192, 199
Baumea (*see* Cladium)
Beaumontia grandiflora Wall., **68**, 250
Bedellia minor Busck, 423
somnulentella (Z.), 423
Belonidæ, 363
Beroë sp., 483
Bidens pilosa Linn., **53**, 196
Bignonia gracilis H. B. K.=**Bignonia unguis-cati** Linn., 248
unguis-cati Linn., **68**, 250
venusta Ker-Gawl., **68**, 248, 250
Blattodea, 428
Blenniidæ, 353
Bœrhaavia diffusa Linn., **51**, **192**
Bœhmeria nivea Hook. & Arn., 217
Bombyx mori Linn., 397
Bos bufalus, 277
Bostrichus migrator Sharp, **99**, 406
Bostrychidæ, 418
Bougainvillea, **66**, 240
spectabilis Willd., 247
Bowersia violescens Jord. & Evermann, **91**, 362, 349
Brachiopods, 483
Brachymetopa, 429
discolor Redt., **97**, 392
Brachyura, 469
Brissus carinatus, 487
Bromeliaceæ, 261
Broussaisia pallucida Gaud., **62**, 224
Broussonetia papyrifera Vent., 217
Bruchus obtectus Say, **405**, 418
prosopis Le Conte, 395
Bryophyllum calycium Salisb., **66**, 240, 208
Bryozoa, **28**, 116
Buccinidæ, 450
Budleya Asiatica, **59**, 214
Buenoa pallipes (Fabr.), 426
Bufo columbiensis, **96**, 384
Bulimella bacca Reeve, **103**, 448
Bullidæ, 467
Bulweria bulweri (Jard. & Selby.), **78**, 310
Buprestidæ, 417
Buteo solitarius Peale, **80**, 323, **81**, 327, 336
Byronia (*see* Ilex)

C

Cadakia = (Lucina) ramulosa Gould, 456, 445
Cæcidæ, 463
Cæsalpinia pulcherrima Swtz., 244
Calandra oryzæ (Linn.), 395, 405, 418
Calappa hepatica (Linn.), **108**, 474
Calcinus elegans (Milne Edwards), **108**, 472
latens (Randall), **108**, 474
Calidris arenaria (Linn.), 324
Calliphora dux Esch., **99**, 406
Callithmysus, 418
Callydon lauia (Jord. & Everman), 349
miniatus (Jenkins), **93**, 370, 349, 365
perspicellatus (Steindachner), 365
Calophyllum Inophyllum Linn., 201, 247
Calotermes castaneus Brum., 425
marginipennis Latr., 402, 425
Calotomus sandvicensis (Cuv. & Val.), 365
Calyptræidæ, 462
Campanularia, 481
Camponotus maculatus Fabr., **99**, 406
maculatus var. hawaiiensis Forel, 403
Campylotheca sp., **61**, 220
Campylotheca spp., 227
Canna, 391
Indica Linn., 207
Cantharus, 450
sp., **106**, 470
Cantherines sandwichiensis (Quoy & Gaim.), 349
Canthigaster epilamprus (Jenkins), **93**, 370
Canthigasteridæ, 367
Capparis Sandwichiana D. C., **51**, 192, 199
Carabidæ, 416
Caradrinidæ, 420, 422
Caradrinina, 420
Carangidæ, 364
Carangoides ferdau (Forskal), **91**, 362
Carangus (large size), 349
(small size), 349
affinis (Ruppell), **92**, 366
ignobilis (Forskal), **91**, 362, 364
melampygus (Cuv. & Val.), 349
Carassius auratus (Linn.), 376
Carcharias melanopterus Q. & G., **86**, 340
Carcharodon carcharias (Linn.), **87**, 344, 345
Cardium orbiter Reeve, **104**, 456, 446
Carelia, 434
sinclairi Ancey, **103**, 448
Carex Oahuensis C. A. Meyer, **58**, 212
sp. 192
Carica (*see* Papaya)
Carica Papaya Linn., **70**, 264
Carpilius convexus (Forskal), **108**, 472
maculatus (Linn.), **108**, 474
Carpilodes monticulosus A. Milne Edwards, **110**, 482
Carpodacus mexicanus obscurus McCall, 304
Caryoborus gonagra (Fabr.), 395
Caryota urens Linn., 237
Cassia Fistula Linn., 244
grandis Linn., 244
nodosa Buch., 244
sp. **68**, 250
Cassidæ, 461
Cassis cornuta Linn., 461
vibex Linn., 461
vibex var. Linn., **105**, 460
vibex var. erinacea Linn., 461
Casuarina equisetifolia Linn., 237
Cavia cutleri, 293
Cenchrus echinatus Linn., 287
Centrolypus sp., 427
Cephalacanthidæ, 357
Cephalacanthus orientalis (Cuv. & Val.), **94**, 374, 357

Cephalopoda, 441
Cerambycidæ, 417
Cerataphis lantaniæ (Boisd.), 389
Ceratiidæ, 369
Ceratitis capitata (Wied.), **99**, 406, 386
Cereus triangularis Haw., **67**, **246**, **254**
Cerithiidæ, 464
Cerithium, 464
columna Sowb., **106**, 470, 464
obeliscus Brug., **106**, 470, 464
Cervus axis Erxl., 296
Cetacea, 300
Chætodon, 353
lunula (Lacep.), 349
miliaris Quoy. & Gaim., **93**, 370
unimaculatus Bloch, **93**, 370
Chætodóntidæ, 353
Chætogædia monticola (Big.), **99**, 406
Chætoptila angustipluma (Peale), **83**, 332, 335
Chalcolepidius erythroloma Cand., **99**, 406
Chama, 117, 446
sp., **104**, 456
Chamidæ, 446
Chanos chanos (Forsk.), **87**, 344, 349, 360, 363
Charadrius dominicus fulvus (Gmel.), **78**, 310, 321
Chasiempis gayi Wilson, **85**, 337, 329
sandvicensis (Gmel.), **85**, 337, 329
sclateri Ridgw., **84**, 334, 329
Cheilinus sp., 359
Cheilio inermis (Forskal), 349
Cheirodendron platyphyllum Seem., **62**, 220
Chelifer hawaiiensis Simon, 408
Chelone imbricata (Linn.), 300
mydas (Linn.), **76**, 294, 300
Chelonobia testudinaria (Linn.), **108**, 474
Chenopodium Sandwicheum Moq., **79**, 316
Chilocorus circumdatus (Schoen.), 394
Chilomycterus affinis Günther, 349
Chilopoda, 407
Chitonidæ, 467
Chloridops kona Wilson, **82**, 330, 338
Chloris radiata Sw., **53**, 196
Chlorodrepanis spp., 329
stejnegeri (Wilson), **84**, 334
wilsoni (Roths.), **83**, 332
Chondria tenuissema, 501
Chordata, 484
Chrysomphalus ficus Ashm. = Chrysomphalus aonidum (Linn.), 391
ficus Ashm, **66**, 384
Chrysopa microphya McLachl., 424
Chrysopogon aciculatus Trin., 286
verticillata (L.), Scribon, **53**, 196
Cibotium, **50**, 91, **63**, 228
Chamissoni Brack., 222
Menziesii Hook., **50**, 191, 222
sp., **52**, 194
Cimex lectularius Linn.=**Klinophilos lectularius** (Linn.), 402
Cinnamomum camphora T. Nees & Eberm., 262
Zeylanicum Nees, 262
Cioidæ, 418
Ciridops anna (Dole), **82**, 330
Cirrhitidæ, 354
Cirrhitus marmoratus (Lacep.), **94**, **374**, **349**
Cirripedia, 473
Cistelidæ, 418
Citrullus vulgaris Schrad., 269
Citrus acida Hook. = Citrus **medica Limetta**, 265
Aurantium Linn., 263
Decumana Linn., 265
Japonica Thumb., 265
Limon Linn. = Citrus **medica limonum**, 265
Cladiophiuræ, 491
Cladium (Baumea) Meyenii Kth., **57**, **206**, **62**, 224
Clarias fuscus (Lacepede), 377
Cleridæ, 417
Clermontia, 226
macrocarpa Gaud., **58**, 212
persicæfolia Gaud., **59**, 214
Clerodendron Thomsonæ Balf., **66**, **240**
Clubionidæ, 409
Clupeidæ, 358
Clytarlus, 418
Clytus crinicornis Chevr., **99**, 406
Coccidæ, 391, 427
Coccinellidæ, 393, 416
Coccus viridis (Green), 391
Cocos nucifera Linn., 201, 233
Codiæum variegatum Linn., **64**, 234, **251**
Cœlastrea sp., **111**, 486
tenuis Verrill, **111**, 486
Cœlenterata, **28**, 116, **113**, 490, **475**
Cœlophora inæqualis (Fabr.), 394
pupillata (Schoen.), 393
Coffea Arabica Linn., **50**, 191, 279
Liberica Hiern., 279
Coix lacryma Jobi Linn., **54**, 198, 207
Coleoptera, 388, 394, 412, 415, 418
Coleotichus blackburniæ White, **98**, 398
Coleus, 251
Collembola, 430
Columbella turturina Lam., **106**, 470, 453
varians Schwb., **106**, 470, 101, 453
zebra Gray, **106**, 470, 453
Columbellidæ, 453
Colubrina Asiatica Brongn., 204
oppositifolia Brong., 215
Compositæ sp., **59**, 214
Conidæ, 453
Conocephaloides hawaiiensis Perkins, 429
Conus, 117
hebræus Linn., **105**, 460, 454
litteratus var millepunctatus Lam., **454**
lividus Hwass., **105**, 460
miliaris Hwass., **105**, 460
pulicarius Hwass., **105**, 460, 454
quercinus Hwass., **105**, 460, 454
Coprosoma ernodeoides Gray, 256
spp., 227
Coptops ædificator Fabr., **99**, 406
Cordia subcordata Lam., **54**, 198, 201

Cordyline terminalis Kunth., **50**, 191, 210, 251
Corixa (*see* Arctocorisa), 426
Corixidæ, 426
Coronula sp., 475
Corvus hawaiiensis Peale, **81**, 327, 335
Coryphæna hippurus Linn., **91**, 362, 349, 354
Cosmophila sabulifera (Guen.), 397
Crabro, 413
Crambidæ, 420
Crangon = (Alpheus) lævis (Randall), **110**, 482
Cremastobombycia lantanella Busck, 385
Crepidula, 447, 462
aculeata Gmel., **106**, 470
Crinoidea, 497
Crotalaria sp., **53**, 196
Crucibulum, 462
Crustacea, **28**, 116, 468, 469
Cryptolæmus montrouzieri Muls, 394
Cryptophlebia illepida (Btl.), 397
Cryptorhynchus mangiferæ (Fabr.), **99**, 406, 395
Ctenocephalus canis=**Pulex canis Duges**, 401
Ctenophoræ, 483
Culicidæ, 419
Cucumus Melo Linn., 269
Cucurbita maxima Duch., 209
Culex fatigans Wied., 387
Cupressus macrocarpa Hartw., 237
Curculionidæ, 418
Cuscuta sandwichiana Chios., 201, 204
Cyanea angustifolia Hbd., **62**, 220
Cyathodes Tameiameiæ Cham.=**Styphelia Tameiameia** Cham., 225, 230
Cycas circinalis Linn., 237
revoluta Thumb., 237
sp., **66**, 240
Cylas formicarius (Fabr.), 418
Cynodon dactylon (L) Kuntz., **19**, 90, 208, 286
Cyperus alternafolia Linn., **64**, 234
pennatus Lam., **54**, 198
rotundus Linn., 287
Cyphastrea, 479
Cyphastrea ocillina (Dana), **111**, 486
Cypræa, 447
arabica Linn., 459
carneola Linn., var., **106**, 470, 458
caput-serpentis Linn., **106**, 470, 458
helvola Linn., 458
isabella Linn., **106**, 470, 458
madagascariensis Gmel., **106**, 470, 459
mauritiana Linn., **106**, 460, 458
moneta Linn., **106**, 470, 458
reticulata Mart., **105**, 460, 459
semiplota Migh., **106**, 470
suleidentata Gray, **105**, 460
tigris Linn., 459
Cypræidæ, 457
Cypranus carpio, 376
Cypsilurus simus (Cuv. & Val.), **92**, 366, 349
Cyrenidæ, 440
Cyrtandra sp., **59**, 214
Cytherea, 446
Cytherea = (Liochoucha) hieroglyphica Conrad, **104**, 456

D

Dacus cucurbitæ Coq., **99**, 406, 387
Dafila acuta Linn., 328
Dardanus gemmatus (Milne Edwards), **108**, 472
Dasyatis hawaiiensis Jenkins, **86**, 340
Datura Stramonium Linn., **54**, 198, 287
Deilephila calida Butl., **98**, 398
lineata (Fabr.), **98**, 398
smaragditis Meyr., 420, 421
Delphinus delphis Linn., 301
Dermaptera, 428
Dermestes cadaverinus Fabr., 405
Dermestidæ, 417
Dendrophillia manni (Verrill), 479
Desmodium uncinatum = (Meiobemia uncinatus) D. C., **53**, 196
Diadema paucispinum, 487
Dianella ensifolia (Linn.), D. C., **56**, 202
Diaspis bromeliæ (Kern.), **96**, 384, 391
Dinoderus minutus (Fab.), 405, 418
Diodon nudifrons Jenkins, **93**, 370, 365
Diodontidæ, 365
Diomedea immutabilis Roths., **20**, 92, 313
nigripes Aud., **78**, 310, 312
Dioscorea sativa Linn., 210
Diplopoda, 408
Diploptera, 414
Diptera, 387, 402, 419
Dolichopodidæ, 419
Doliidæ, 459
Dolium melanostoma Jay, 461
perdix Linn., **105**, 460, 461
Domecia hispida Eydoux & Souleyet, **110**, 482
Dracæna, 211, 251
aurea Mann., **56**, 202, 210
Drepanididæ, 331, 336
Drepanis pacifica (Gmel.), **83**, 332, 333
Drepanorhamphus funereus (Newton), **83**, 332, 335
Drosophila ampelophila Loew., 420
Drosophilidæ, 420
Dubautia, 227 (*Dubautia* = *typog. error*)
laxa Hook. & Arn., **61**, 220
plantaginea Gaud., **61**, 220
Dytiscidæ, 416

E

Echeneis sp., 368
Echidna nebulosa (Ahl.), **88**, 350, 361
Echinodermata, **28**, 116, 485, 493
Echinometra, **116**, 496
sp., **116**, 496, 485
Echinothrix desori, 487
Echthromorpha maculipennis Holmgr., **99**, 406
Eclipta alba Hassk., **53**, 196
Elæocarpus bifidius Hook. & Arn., **56**, 202

Elæis guinensis Jacq., 237
Elaphoglossum = (Scrostichum) conforme SW., **63**, 228
Elateridæ, 417
Eleocharis (*see* Scirpus)
Eleotris sandwicensis Vaillant & Sauvage, **94**, 374, 349, 357
Eleusine Indica Garrtn., **53**, 196
Eleutheroda dytiscoides Coqueb., **97**, 392, 388
Elimæa appendiculata Brunn., **97**, 392, 429
Elisus lævimanus Randall, **108**, 474
Elopidæ, 364
Elops saurus Linn., 360
Embiidæ, 425
Endodonta sp., **103**, 448.
Endodontidæ, 439
Engina, 453
farinosa Gould, 453
Enneapterygius atriceps (Jenkins), **94**, 374, 353
Entiromorpha spp., 501
Eopenthes, 417
Epinephelus quernus Seale, **91**, 362, 349, 369
Epitragus diremphus Kersch., **99**, 406
Epitrix parvula (Fabr.), 395
Eragrostis major Host., **53**, 196
variabilis Gaud., **62**, 224
Erato sandwicensis Pease, 452
Erigeron Canadensis Linn., **58**, 212, 287
Erinna newcombia A. Adams, 438
Eriobotrya Japonica Lindl., 266
Erythrina monosperma Gaud., **52**, 194, 203, 210
Etelis marshi (Jenkins), **91**, 362, 349, 371
Ethmia colonella. Walsm., **98**, 398
Etisus lævimanus Randall, **110**, 482
Etrumeus micropus (Schlegel), **87**, 344, 349, 358
Euchenididæ, 367
Eucolia impatiens Say, 387
Eugenia (*see also* Jambosa)
Eugenia Jambolana Lam=**Syzygium Jambolana** (Lam), 268
Jambos Linn. = Eugenia (Syzygium) Jambolana, 267
Malaccensis (Linn.)=**Jambosa Malaccensis** (Linn.), 216
Mitchelii Lam. = **Eugenia uniflora** Linn., 267
Euleptorhampus longirostris (Cuvier), **88**, 350
Eulima, 463
Eulima major Sowb., **106**, 470, 463
sp., **106**, 470
Eulimidæ, 463
Eulota similaris Fer., **103**, 448, 439
Eumenidæ, 414
Euphorbia clusiæfolia Hook. & Arn., **59**, 214, **61**, 220
cordata Meyen., **51**, 192
geniculata Ort., **53**, 196
lorifolia Hbd., 283
multiformis Hook. & Arn., **58**, 212
pulcherrima Willd., **249**
pilulifera Linn., **53**, 196
Euphorbiaceæ, 249, 283
Euplexoptera, 415
Eurnella, 434
Euthyrrhapha pacifica. (Coqueb.), **97**, **392**
Eutreta sparsa, 385
Euxesta annone (Fabr.), 388
Euxolus viridis Moq., **53**, 196
Eviota epiphanes Jenkins, **94**, 374, **357**
Exocœtidæ, 355
Exocœtus volitans Linn., 349

F

Favia, 479
Felis domestica Linn., 293
Ficus Benghalensis Linn., 245
Carica Linn., 245, 266
elastica Roxb., 245, 283
Indica Linn., **67**, 246
pumila Linn., 245
religiosa Linn., **66**, 240, 283
Fissurellidæ, 466
Fragaria Chilensis Ehrh., 255
Frangilla canaria Linn., 319
Fregata aquila Linn., **78**, 310, 313
Freycinetia Arnotti Gaud., **50**, 191, **56**, **202**, **60**, 218, 211
Fulgoridæ, 427
Fulica alai Peale, **80**, 323, 326
Fundulus grandis, 378
Fungia sp., **112**, 488
Fungiidæ, 479
Fusidæ, 450
Fusus novæ-hollandiæ Rve., **105**, 460, **450**
Formicaleo purjurus (Walk.), 425
Formicidæ, 413
Formicina, 403
Fossaridæ, 465

G

Gahnia Beecheyi Mann, **62**, 224
Galleriidæ, 420
Gallinula sandvicensis Streets, **80**, 323, **326**
Gambusia affines, 378
Garcinia mangostana, 269
Morella Desr., **67**, 246
xanthochymus, 269
Gastrophilus equi. (Clark), **99**, 406, 387
Geckonidæ, 297
Gelechia gossypiella (Sndrs.), 400, 423
Gephyrea, **113**, 490, 116, 499
Geranium Carolinianum Linn., 287
Germo germo (Lacep.), 349, 361
Gerridæ, 426
Gleichenia dichotoma Hook., 223
Gleichenia linearus (Burm.) Clarke=(Gl. dichotoma Hook.), **52**, 194, **63**, 228
longissima Bl., **63**, 228, 253
Gobiidæ, 355
Gomphosus sp., 359
Goniodes stylifer Nitzzch., 400

Gorgonacea, 479
Gossypium Barbadense Linn., 281
drynarioides Seem., 203, 281
sp., 281
tomentosum Nutt., 199, 203, 281
Grapsus grapsus tenuicrustatus (Herbst.), **108**, 474, 469
Grevillea robusta Cunn., 247
Gryllodea, 429
Gryllodes pocyi Sauss., **97**, 392
Gryllotalpa africana Fabr., **97**, 392, 388, 430
Gryllus innotabilis Walk., 430
sp., 430
Gunnera petaloidea Gaud., **52**, 194, 225
Gygis alba kittlitzi Hart., **78**, 310, 318
Gymnosarda alletterata (Rafinesque), **92**, 366, 349
pelamis (Linn.), **92**, 366, 349, 361, 363
Gymnothorax, 349, 361
undulatus (Lacép.), **88**, 350, 361
ercodes Jenkins, **88**, 350
petelli (Bleeker), **88**, 350
Gynerium argenteum Stapf., **65**, 238
Gynopogon (*see* Alyxia)

H

Hæmatobia serrata Desv., 387
Hæmatopinus urius Nitzsch., 400
Haliseris plagiogramma Mont., 222
Haptoncus sp., 388
Harpa conoidalis Lam., **105**, 460, 452
Harpinæ, 452
Helicidæ, 439
Helicina sp., **103**, 448
Helcioniscus exaratus Nutt., **105**, 460, 466
Heliophila unipuncta (Haw.), 396
Heliothis, 422
Heliothrips haemorrhoidalis Bouche, 428
rubrocinctus Giard., 428
Heliotropium anomalum Hook & Arn., **54**, 198, 199
Curassavicum Linn., **51**, 192, 199
Helicinidæ, 438
Hemerobiidæ, 424
Hemignathus lichtensteini Wilson, **83**, 332
obscurus (Gmel.), **82**, 330
procerus Cab., **82**, 330
Hemiptera, 389, 400, 402, 412, 425
Hemiramphidæ, 358
Hemiramphus depauperatus Lay & Bennett, **88**, 350, 349, 358
Herpestes griseus Geoff., 296
Hepatica, **59**, 214
Hepatus achilles (Shaw), 349, 372
Hepatus dussumieri (Cuv. & Val.), 349
elongatus (Lacep.), 349
guntheri (Jenkins), **93**, 370, 372
olivaceus (Bloch & Schneider), **93**, 370, 372
sandvicensis (Streets), **91**, 362, 349, 372
xanthopterus (Cuv. & Val.), 349
Heteractitis incanus (Gmel.), **78**, 310, **80**, 323, 324
Heterocentrotus sp., 487
Heteropoda regia Fabr., 409, 410
Heterorhynchus affinis Roths., **84**, 334
hanapepe (Wilson), **82**, 330
lucidus (Licht.), **82**, 330
wilsoni Roths., **83**, 332
Heteropogon (*see also* Andropogon)
Heteropogon = (Andropogon) contortus R. & Sch., 286
Hevea Braziliensis Muell., 283
Hibiscus (*see also* Paritium)
Hibiscus, 391
Arnottianus Gray, **56**, 202, 213
Brackenridgei Gray, 213
Kokio Hbd., 213
tiliaceus Linn., **54**, 198
Youngianus Gaud., 213
Himantopus knudseni Stejn., **81**, 327, 310, 325
Himatione freethi Roths., 314
sanguinea (Gmel.), **84**, 334, **85**, 337, 329
Hinnites giganteus Gray, **104**, 456, 445
Hippa adactyla Fabr., **110**, 482
Hippoboscidæ, 420
Hippocampus, 365
fisheri (Jord. & Evermann), **88**, 350
Hipponyx, 462
Hipponyx antiquatus Linn., **106**, 470, 462
barbatus Sowb., **106**, 470, 462
imbricatus Gould., **106**, 470, 462
Hirundinea, 440
Histeridæ, 417
Holocentridæ, 371
Holocentrus spp., 371
microstomus Günther, **92**, 366
Holothuria atra Jager., 493
cinerascens (Brandt), 493
pardalis Selenka, 493
vagabunda Selenka, 493
Holothuroidea, 491
Homarus americanus (M-Edw.), 468
Hormiphora fusiformia, 483
Homoptera, 427
Hoya carnosa R. Br., 248
Hydatina amplustra Linn., **106**, 470, 467
Hydra, 475
Hydriomenidæ, 397, 420
Hydrobius semicylindricus Esch., **101**, 436
Hydrocorallinæ, 481
Hydromedusæ, 480
Hydrophidæ, 299
Hydrophilidæ, 416
Hymenoptera, 403, 412
Hydrus platurus Linn., 299
Hyophorbe amaricaulis Mart., 237
Hypoderma bovis DeG., 387
lineata (Villiers), 387
Hyposmocoma, 423
Hypothenemus sp., 388

I

Ianthina exigua Lam., **106**, 470, 464
fragilis Lam., **106**, 470, 464
globosa Swain., **106**, 470, 464

Ianthinidæ, 463
Icerya purchasi Mask., 391, 393
Idiopterus nephrolepidis Davis, 389
Ilex = (Byronia) Sandwicensis Endl., **59**, 214, **62**, 224
Imbricaria, 451
Indigofera Anil Linn., **58**, 212, 207
Inga dulcis Willd.=**Pithecolobium dulce** (Roxb.), **54**, 198
Insecta, 409
Ipomœa (*not* Ipomæa), 197
Batatas Lam., 197, 284
bona-nox Linn., **56**, 202
chryseides Ker., 248
insularis Steud., 197
pes-capræ Sw., **51**, 192, **60**, 218, 197
tuberculata Roem. & Sch., **51**, 192, 197
Ischnochiton sp., **106**, 470
Isometrus maculatus De Geer, **98**, 398, 407
Isopoda, 408
Isoptera, 402
Isuropsis glauca (Mull. & Henle), **86**, 340
Ixora, 249
Ixoreæ, 249

J

Jacquemontia Sandwicensis Gray, **51**, 192
Jambosa (*see also* Eugenia)
Jambosa, 216
Jambosa = (Eugenia) Malaccensis Linn., 256
Jasminum Sambac Soland., 248
grandiflorium Linn., **68**, 250, 248
Julis, 359
spp., 359
lepomis (Jenkins), **93**, 370
Jussiæa villosa Lam., **58**, 212

K

Kadua sp., **61**, 220
Klinophilos (*see* Cimex)
Kuhlia malo (Cuv. & Val.), **92**, 366, 349, 358
Kuhliidæ, 358
Kyllingia obtusifolia=**Kyllingia monocephala Rottb.**, 58, 212
monocephala Rottb., **53**, 196, 287

L

Labridæ, 359, 365
Lagenaria vulgaris Ser., 209
Lamellibranchiata, 443
Laminella, 123, 434
gravida Fer., **103**, 448
sanguinea Newc., **103**, 448
venusta Migh., **103**, 448
Lantana Camara Linn., **54**, 198, 209, 383
Laridæ, 309
Lasioderma sericorne (Fabr.), 395, 405, 418
Lasiurus semotus Harr. Allen., 295
Latania glaucophylla Hort.=**Latania Loddigesii Mart.**, 237
Latirus, 450
Lauraceæ, 262
Laurencia spp., 501
Leguminosæ, 203, 205
Lepadidæ, 473
Lepidaplois spp., 359
Lepidium Virginicum Linn., **287**
Lepidoptera, 388, 395, 396, **411**, **420**
Lepidosaphes pallida (Mask.), **391**
Lepisma saccharina Linn., 403, **431**
Leptachatina, 433, 434, 437
chrysalis Pfeiff., **103**, 448
sp., **103**, 448
Leptastrea, 479
agassizi Vaughan, **111**, 486
hawaiiensis Vaughan, **111**, 486
sp., **111**, 486
Leptodius sanguineus (Milne Edwards), **110**, 482
Lepus sp., 293
Leucæna glauca Benth., **54**, 198, 207
Leucania, 422
Leucophæa surinamensis (Fabr.), **97**, **392**
Lichens, **52**, 194
Limnæa binominis Sykes, **101**, 436, **438**
oahuensis Soul., **101**, 436, 438
Limnæa, 438
Limnæidæ, 438
Limacidæ, 439
Linckia sp., 489
Liochoncha (*see* Cytherea)
Lioconcha hieroglyphica Conrad., **446**
Lipochæta integrifolia Gray, 199
Litchi (*see* Nephelium)
Littorina, 447
obesa Lam., 464
pintado Wood, **106**, 470
scabra Linn., **106**, 470, 464
Littorinidæ, 464
Lobelia hypoleuca Hbd., **62**, 224
sp., **57**, 206
Lobeliaceæ, 225
Locustoidea, 429
Lophocateres pusilla, 405
Lophortyx californica (Shaw), 308
Lophozozymus dodone (Herbst.), **110**, **482**
Loxerates (*see* Aphis)
Loxops, 333
cæruleirostris (Wilson), **85**, 337
ochracea Roths., **83**, 332, **85**, 337
rufa (Blox.), **83**, 332
Lucanidæ, 417
Lucilia cæsar (Linn.), **99**, 406, 387
sericata (Meigen.), **99**, 406, 387
Lucina (*see* Cadakia)
Luidia hystrix Fisher, **116**, 496, 489
Lutianidæ, 369
Lycæna (*see* **Thecla**)
Lycæna bætica Linn. = **Thecla bætica** (Linn.), **98**, 398, 421
blackburni (Tuely.) = Thecla blackburni (Tuely.), 421
Lycænidæ, 385, 420, 421
Lycopodium cernuum Linn., **59**, 214
pachystachyon Spr., **59**, 214
serratum Thbg., **59**, 214

Lyctidæ, 418
Lygæidæ, 425
Lysimachia daphnoides Hbd., 230
Lythrum maritimum H. B. K., **58**, 212

M

Machilis heteropus Silvestri, 431
Macrobrachium grandimanus (Randall), **101**, 436, **110**, 482
Macrolepidoptera, 420
Macrosiphum rosæ (Linn.), 389
sanborni Gillette, 389
Macrophthalmus telescopicus (Owen), **108**, 474
Macrura, 469
Madreporaria, 475, 476
Mallophaga, 400, 430
Malva rotundifolia Linn., **53**, 196
Malvaceæ, 203, 281
Malvastrum tricuspidatum Gray, **53**, 196
Mangifera Indica Linn., **69**, 258, 241
Manihot Glaziovii Müll., 281
utilissima Pohl., 284
Mantoidea, 429
Mapo fuscus (Ruppell), **94**, 374, 357
Marattia Douglassii Baker, 223
Margaritifera fimbriata Dunk., **104**, 456, 444
Marginella, 452
Marginellidæ, 452
Meandrina, 479
Medicago sativa Linn., 286
Megachile, 415
diligens Smith, **99**, 406
Megaptera, 301
boops (Linn.), 302
Meiobemia (*see* Desmodium)
Melania, 438
mauiensis Lea, **101**, 436, 438
newcombii Lea, **101**, 436, 438
Melaniidæ, 438
Melia Azedarach Linn., 244
sempervirens Sw., 244
Melina = (Perna) californica Conrad., **104**, 456, 443
Membracidæ, 427
Metazoa, 499
Metograpsus messor (Forskal.), **101**, 436, **108**, 474, **110**, 482
Metrosideros polymorpha Gaud., **50**, 191, 209, 215
polymorpha var. Gaud., **61**, 220
rugosa Gray, **61**, 220
tremaloides Heller, **61**, 220
Micranous hawaiiensis (Roths.), **78**, 310, **80**, 323, 311
Microlepia strigosa Presl., 222
tenuifolia Metten., **63**, 228
Microlepidoptera, 420, 422, 423
Micropterus salmoides (Lacep.), 378
Microvelia vagans White, 426
Milleporidæ, 481
Mimosa pudica Linn., 287
Mirabilis Jalapa Linn., 254
Miridæ, 426
Mirosternus, 418
Mitra, 447, 451
sp., **106**, 470
tabanula Lam., **106**, 470
Mitridæ, 451
Mobula japonica (Muller & Henle), 347, 349
Modulus tectum Gmel., **106**, 470, 465
Moho apicalis Gould, **82**, 330, 335
bishopi (Roths.), **82**, 330
braccatus (Cassin), **85**, 337
nobilis (Merrem.), **82**, 330, 333
Molienesia lattipinna, 378
Mollusca, **28**, 116, 447
Molluscoidea, 483
Monachus schauenslandi, **76**, 294, 303
Monotaxis grandoculis (Forskal), **92**, 366, 349, 367
Monstera deliciosa Liebn., **67**, 246, 249
Montipora, 477
spp., **111**, 486
Morinda citrifolia Linn., 201, 205
Morus alba Linn., 267, 397
nigra Linn., 267
Mugil cephalus Linn., **91**, 362, 349, 359
Mugilidæ, 359
Mullidæ, 372
Mulloides auriflamma (Forskal), **91**, 362, 349, 373
flammeus (Jord. & Evermann), **92**, 366
Munia nisoria (Temm.), 304
Murænidæ, 361
Murex, 449
Muricidæ, 449
Mus alexandrinus (Goeffroy), 292
decumanus=**Mus norvegicus** Erxleben., 291
musculus Linn., 292, 293
norvegicus Erxleben., 292
rattus Linn., 292
Musa Cavendishii Paxt., **69**, 258, 259
sapientum Linn., **50**, 191, 222
textilis Nees, 280
Musca domestica Linn., 387
Muscidæ, 419
Mycetophilidæ, 419
Myctophidæ, 359
Myodochidæ, 426
Myoporum Sandwicense Gray, 210, 222, 226
Myripristis berndti Jord. & Evermann, **91**, 362, 349, 371
murdjan (Forskal), 349, 371
Myrmeleonidæ, 425
Mytilus, **109**, 478, 443
crebristriatus Conrad., **104**, 456, 443
Myzus citricidus, 389

N

Nabidæ, 426
Nassa, 447, 451
gaudiosa Hinds., 451
hirta Kien., **106**, 470, 451
papillosa Linn., 451
splendidula Dunk., 451
Nassidæ, 451

Nasturtium officinale R. Br., 208
Natica, 447
marochiensis Gmel., **106**, 470
Naticidæ, 461
Naucrates ductor (Linn.), **92**, 366
Nelumbium speciosum=**Nelumbo nucifera** Gaertn., 285
Nelumbo (*see* Nelumbium)
Nemathelminthes, **28**, 116
Nemertinia, **28**, 116, 497
Neoliodes theleproctus Herm., 401
Nephelium Litchi Cambes = Litchi chinensis, 269
Nephrolepis exaltata Schott, **63**, 228
Nertera depressa Banks., **59**, 214
Nerita picea Reelz., **101**, 436, **102**, 442, **106**, 470, 465
polita Linn., **106**, 470, 465
sp., 465
Neritidæ, 439, 465
Neritina, 439, 465
cariosa Gray, **101**, 436, **106**, 470, 466
granosa Sowb., **106**, 470, 439, 466
neglecta Pease, **106**, 470
vespertina Nutt., **101**, 436, **106**, 470, 466
Nerium Oleander Linn., 252
Nerocila australasiæ Schioedte & Meinert, **110**, 482
Nesochen sandvicensis (Vig.), **78**, 310, **80**, 323, 335
Nesoprosopis, 415
Neuroptera, 423
Newcombia, 434
canaliculata var. wailauensis Pils., **103**, 448
Nicotiana glauca Grah., **51**, 192
Tabacum Linn., 283
Nitidulidæ, 417
Notonectidæ, 426
Notodontina, 420, 422
Noctuidæ, 396
Novius cardinalis (Muls.), 393
Nudibranchiata, 467
Numenius tahitiensis (Gmel.), **78**, 310, 324
Nycticorax nycticorax nævius (Bodd.), **78**, 310, 325
Nymphalidæ, 420, 421
Nysius, 426

O

Oceanodroma cryptoleucura (Ridgw.), **80**, 323, 309
Octopus sp., **102**, 442
Ocypode ceratophthalma (Pallas), **108**, 472, **116**, 496, 469
Odonata, 424
Odynerus, 414
nigripennis (Holm.), **99**, 406, 414
spp., 414
Œchalia grisea (Brum.), **98**, 398
Œdemeridæ, 418
Œstridæ, 420
Œstrus ovis Linn., 387
Olea Sandwicensis Gray, 227
Oliva carneola Gmel., 452
erythrostoma Lam., 452
Olividæ, 452
Olivinæ, 452
Omiodes accepta (Butl.), 388, 395
blackburni (Butl.), 395, 422
monogona Meyr., 395
meyricki Swezey, 395
Ompatrum serratum Boisd., 395
Oodemas, 418
Opeas junceus Gould, 439
pyrgiscus Pfeiff., **103**, 448
Opheodesoma spectabilis Fisher, 495
Ophicephalus striatus Bloch, 377
Ophiothrix sp., 491
Ophiuroidea, 487, 489
Opuntia Tuna Mill., 209, 269
Orcus chalybeus (Boisd.), 394
Oreodoxa regia H. B. K., **67**, 246, 232
Oreomyza (*see* Oreomystis)
Oreomystis=(Oreomyza), 331, 338
bairdi (Stejn.), **85**, 337
maculata (Cab.), **83**, 332
montana (Wilson), **83**, 332
Oribata oriformis Pearce, 401
Oribatidæ, 401, 420
Ortalidæ, 388
Orthezia insignis Dough, **96**, 384, 385
Orthodera prasina Brum., 429
Orthoptera, 388, 428
Orthurethra, 121
Oryza sativa Linn., 276
Osteomeles anthyllidifolia Lindl., 215
Ostraciidæ, 375
Ostracion sebæ Bleeker, **94**, 374, 375
Ostrea, 117
lurida Cpr., 445
retusa Sby., 115, 445
rosacea Chem., **104**, 456, 445
virginica Lister., 445
Ovulidæ, 459
Oxya velox (Fabr.), **97**, 392, 388, 429
Oxalis corniculata Linn., **53**, 196

P

Pagiophalus atomarius Simon, 410
Palæmon pacificus (Stimpson), **110**, 482
Palinuridæ, 469
Palmeria dolei (Wilson), **82**, 330
Pandanus odoratissimus Linn., **50**, 191, **52**, 194, 204, 221
Panicum maxima Jacq., 286
Molle SW., 286
pruriens Trin., 286
torridum Gaud., 209
Pantala, 425
flavescens Fabr., **97**, 392, 424
Panulirus japonicus (de Seebold), **108**, 472, 468
Papaya vulgaris D.C. = **Carica Papaya** Linn., 262
Papilionina, 420, 421

Paracirrhites arcatus (Cuv. & Val.) 354
cinctus (Günther), 349
forsteri (Bloch & Schneider), **94**, 374, 354
spp., 354
Parasita, 400
Paratenodera sinensis Sauss., **97**, 392
Paratrigonidium pacificum (Scudd.), 429
Parexocœtus brachypterus (Solander), **92**, 366, 349, 355
Paritium tiliaceum St. Hill=**Hibiscus tiliaceus** Linn., 201
Parribacus antarticus (Lund), **108**, 472
Partulina, 434
confusa Sykes, **103**, 448
Paspalum conjungatum Berg., 208, 286
orbiculare Forst., 209, 286
Passer domesticus Linn., 304
Passiflora cærulea Linn., 268
edulis Tims., **69**, 258
laurifolia Linn., 268
quadrangularis Linn., **70**, 264, 268
Passifloreaceæ, 268
Patella sp., **106**, 470
Patellidæ, 466
Pavonia, 479
Pecten., 445
sp., **104**, 456
Pectinidæ, 445
Pediculidæ, 400
Pediculus capites De Geer, 400
vestimenta Nitzsch, 400
Pelea anisata Mann., 221
clusiæfolia Gray, **61**, 220
Pelecypoda, 443
Pelopæus cæmentarius (Drury), **99**, 406, 413
Pennatulacea, 479
Pennula ecaudata King, **81**, 327, 333
Pentalonia nigronervosa Coq., 389
Peperomia sp., **56**, 202
Perdicella, 434
fulgurans Sykes, **103**, 448
Peregrinus maidas Ashm., **98**, 398, 389
Perinea tumida Dana, **110**, 482
Periplaneta americana (Linn.), **97**, 392, 402, 428
australasiæ (Fabr.), **97**, 392, 402, 428
Peristernia, 450
chlorostoma Sby., **106**, 470
Peristerniinæ, 450
Perkinsiella saccharicida Kirk., **98**, 398, 381, 427
Perna (*see also* Melina)
Perna sp., **104**, 456, 443
Perottetia Sandwicensis Gray, **5**, 40
Petrea volubilis Linn., **68**, 250, 248
Persea gratissima Gaertn., **69**, 258, 261
Phæornis myadestina Stejn., **85**, 337
obscura (Gmel.), **84**, 334
palmeri Roths., **82**, 330
spp., 331
Phaëthon lepturus Lacep. & Daun., 309
rubricauda Bodd., **78**, 310, 309
Phasianus torquatus Gmel., 307
versicolor Vieill., 308
Phasianella, 466
Pheidole megacephala (Fab.), 403
Phenacaspis eugeniæ (Mask.), 391
Philodendron, **64**, 234, 249
Philomycidæ, 439
Philonesia baldwini Ancey, **103**, 448
sp., **103**, 448
Phicœma sp., **116**, 496, 491
Phœnix dactylifera Linn., **67**, 246, **70**, 264, 233
Phormium tenax Linn., 281
Phthirus pubis Linn., 400
Phthorimæa operculella (Z.), 423
Phycitidæ, 420
Phyllanthus roseo-pictus Hort., 252
Phyllodromia hieroglyphica Brunn., **97**, 392
obtusata Brunn., 428
Phyllostegia grandiflora Benth., **59**, 214
sp., **59**, 214
Phylodendron, **66**, 240
Phymodius nitidus Dana, **110**, 482
Physalia utricula, **113**, 490, 481
Physalis Peruviana Linn., 257
Physeter macrocephalus Linn., 301
Phytophaga, 417
Pieridæ, 420, 422
Pieris rapæ Linn.=**Pontia rapæ** (Linn.), 399, 422
Piophila casei (Linn.), 405
Piper methysticum Forst., 216
Pipturus albidus Gray, **58**, 212, 217
Pipunculidæ, 419
Pisania, 450
Pisaniinæ, 450
Pisces, **28**, 116
Pisidium, 440
Pisonia umbellifera Seem., **59**, 214
Pithecolobium (*see* Inga)
Pithecolobium Samang Griseb., 242
Pittosporum glabrum Hook. & Arn., **58**, 212
spathulatum Mann, **61**, 220
Plagithmysus, 418
Planamastra, 434
Planaxidæ, 465
Planaxis lineatus DaCosta., 465
Plantago major Linn., **58**, 212, 287
Platyhelminthes, **28**, 116
Platypodia cydouxii (A. Milne Edwards), **110**, 482
Platyomus lividigaster Muls., 393
Platophrys pantherinus (Ruppell), 349, 371
Platyptilia sp., 383
Pleuronectidæ, 371
Plumbago Capensis Thumb., 254
Plumeria sp., 253
Plumularia, 481
Plusia chalcites Esp., 397, 422
Plusiadæ, 397, 420, 422
Pocillopora, 477
sp., **112**, 488
spp., **112**, 488
Podophora pedifera, **116**, 496, 487
Podophthalmus vigil (Fabr.), **108**, 472
Pœciliidæ, 378
Poinciana regia Boj., 243

Polistes aurifer Sauss., 404, 414
hebræus (Fabr.), **99**, 406, 404
Polychæta, 497
Polydactylus sexfilis (Cuv. & Val.), 349
Polypodium spectrum Kaulf., **63**, 228
tamariscinum Kaulf., **63**, 228
Polystichum (*see* Aspidium)
Polyzoa, 480, 483
Ponera perkinsi Forel, 413
Pontia (*see* Pieris)
Pontia rapæ (Linn.), **97**, 392
Porcellio scaber Latr., **98**, 398, **101**, 436, 408
Porifera, **28**, 116, 499
Porites, 477
sp. **112**, 488
spp., **111**, 486
Porpita pacifica, 481
Portulaca oleracea Linn, **53**, 196, 287
Portunus sanguinolentus (Herbst.), **108**, 474
Priacanthidæ, 354
Priacanthus alalaua Jord. & Evermann, **92**, 366
cruentatus (Lacep.), 349, 354
Priofinus cuneatus (Salvin), **78**, 310, **81**, 327, 312
Prionace glauca (Linn.), **86**, 340
Pritchardia Gaudichaudii H. Wendl., 236
Martii H. Wendl., 236
Prodelphinus, 300
attenuatus (Gray), 300
Prosopis juliflora D. C., **66**, 240, 242
Proterhinidæ, 419
Proterhinus, 419
Protoparce=(Sphinx) convolvuli (Linn.), 399
Protovertebrata, 484
Protozoa, 499
Prozanula palmeri Froh., 314, 318
Prunus Persica Sieb. & Zucc., 267
Pseudocheilinus octotænia Jenkins, 349
Pseudococcus bromeliæ (Bouche), 391
citri (Risso), 391
filamentosus (Ckll.), 391
nipæ (Mask.), 391
sacchari (Ckll.), 389
saccharifolii (Green), 389
sp., 391
Pseudolus longulus (Boh.), 395, 418
Pseudonestor xanthophrys Roths., **82**, 330
Pseudoscarus jordani Jenkins, **93**, 370, 365
Pseudoscorpiones, 408
Pseudosquilla ciliata (Fabricius), **110**, 482
Pseudupeneus bifasciatus Jord. & Evermann, **92**, 366, 373
multifasciatus (Quoy & Gaim.), 373
porphyreus Jenkins, **91**, 362, 349, 373
spp., 373
Psidium Guayava Linn.=**Psidium Guajava Linn.**, 70, 264, 263
Cattleyanum (Sabine), 263
Psittacirostra psittacea (Gmel.), **85**, 337, 331
Psocidæ, 424, 425
Psychodidæ, 419
Pteris, 419
aquilina Linn., 223
decipiens Hook., 223
Pterocera aurantia Lam., 457
Pterodiscus, 123, 434
discus. Pils. & Vann., **103**, 448
rex. Sykes, **103**, 448
Pterophoridæ, 420
Puffinus nativitatis Streets, **78**, 310, **312**
newelli Henshaw, 309
Pulex (*see* Ctenocephalus)
Pulex irritans Linn., 401
Pulmonata, 434
Pulvinaria mammeæ Mask., 391
psidii Mask., 391
Punica Granatum Linn., 269
Pupa sp., **103**, 448
Pupidæ, 439
Purpura, 117, 449
aperta Blainv., **105**, 460
sp., **105**, 460
Pyralididæ, 420
Pyralidina, 420, 422
Pyralis mauritialis Boisd., **98**, 398
Pyramidella mitralis Ads., 463
sulcata Ads., 463
terebellum Mull., **106**, 470, 463
Pyramidellidæ, 463
Pyraustidæ, 420, 422
Pyrrhocoridæ, 426
Pyrus Malus Linn., 267

R

Raillardia, 226
Rana catesbiana, 299
Ranella, 449
Ranzania makua Jenkins, **94**, 374, 358
Ravenala Madagascariensis J. F. Gmel., **65**, 238, 257
Reduviidæ, 426
Reduviolus, 426
Reptilia, **28**, 116
Reynoldsia Sandwicensis Gray, 203, 209
Ricinula, 449
ricinus Linn., **106**, 470
Ricinus communis Linn., 285
Risella spp., 465
Rissoidæ, 465
Rhabdoenemis = (Sphenophorous) obscurus (Boisd.), **95**, 380, **99**, 406, 383
Rhanthus pacificus Sharp, **101**, 436
Rhapis flabelliformis L'Herit., 237
humilis Blume., 237
Cochinchinensis Mart., **66**, 240, 237
Rhipicephalus sanguineus, 401
Rhodacanthis palmeri Roths., **83**, 332
Rhopalosiphum violæ, 389
Rhymodius ungulatus (Milne Edwards), **110**, 482
Rhynochophora, 418
Rhynchospora thyrsoidea Nees & M., **62**, 224
Rhyncogonus, 418
Rollandia calycina G. Don., **58**, 212, **62**, 220
Rubiaceæ, 249

Rubus Jamaicensis, **69**, 258
Macræi Gray, 256
Roosevelti = (Apsilus) brighami (Seale), 369
Rotifera, **28**, 116

S

Saccharum officinarum Linn., 272
Sadleria, **50**, 191
cyatheoides Kaulf., **63**, 228, 222
pallida Hook. & Arn., 222
Souleytiana Hbd., 222
Saissetia hemispherica (Targ.), 391
nigra (Niet.), 391
oleæ (Bern.), 391
Salaris zebra Vaillant & Sauvage, **94**, 374, 353
Santalum ellipticum Gaud., 219
Freycinetianum var. littorale Hbd., **51**, 192, 199
Haleakalae Hbd., 219
Sarcophaga barbata Thoms., **99**, 406, 387
Sarcophaga pallinervis Thoms., 387
Sarcophagidæ, 419
Sarcoptes scabei Linn., 401
Sassafras officinale Nees, 262
Saurida gracilis (Quoy & Gaim.), 349
Scævola Chamissoniana Gaud., **56**, 202, 222
Koenigii Vahl., **19**, 90
Lobelia Linn.=**S. frutescens.**, 195
mollis Hook. & Arn., **61**, 220
Scalaria lamellosa Lam., **106**, 470, 464
sp., **106**, 470
Scalariidæ, 464
Scaphandridæ, 467
Scarabeidæ, 417
Scaridæ, 365
Sceliphron cæmentarium (Drury), 404
Scenopinidæ, 419
Schinus Molle Linn., **66**, 240, 245
Scincidæ, 397
Scirpus lacustris Linn., **54**, 198, 199
Scirpus palutris Linn.=**Eleochris palustrus** Linn., **54**, 198
Scolopendra rapens Wood, **98**, 398, 405
Scolytidæ, 419
Scomber, 349
japonicus Houttuyn, **92**, 366, 349, 361
Scomberoides tolooparah (Ruppell), 349
Scombridæ, 361
Scorpænidæ, 368
Scorpænopsis gibbosa (Bloch & Schneider), **94**, 374, 368
Scoparia, 422
Scorpionida, 407
Scotorythra, 422
Scrotichum (*see* Elaphoglossum)
Scyllarides squammosus (Milne Edwards), **108**, 472, 469
Scyphomedusæ, 480
Selidosemidæ, 420
Senebiera didyma Pers., 287
Seriola purpurascens Schlegel, **91**, 362, 349
Serranidæ, 369
Sertularia, 481
Sesuvium Portulacastrum Linn., **51**, 192
Sicydium stimpsoni Gill, **94**, 374, 3[illegible]
Sida cordifolia Linn., 209
fallax Walp., 209
rhombifolia Linn., 209
spinosa Linn., **51**, 192, **53**, 196
spp., 203
Silphidæ, 416
Simocarcinus simplex (Dana), **110**, 482, **116**, 497
Simodactylus cinnamomeus Boisd., **99**, 406
Siphanta acuta (Walk.), **98**, 398, 402
Siphonaptera, 401, 419
Siphonophoræ, 481
Sipunculoidea, 499
Sistrum, 449
morus Lam., **106**, 470, 449
Sitotroga cerealella (Ol.), **405**, 423
Smaragdinella viridis Q. & G., **106**, 470, 467
Smilax Sandwicensis Kth., **56**, 202, 213
Solanum aculeatissimum Jacq., **58**, 212
triflorum, **58**, 212
tuberosum Linn., 284
Solariidæ, 463
Solarium cingulum Kein., 463
perspectivum Linn., **106**, 470, 463
Soleidæ, 371
Solmaris insculpta, 480
Sonchus oleraceus Linn., **53**, 166
Sophora chrysophylla Seem., 226
Spalangia hirta Hal., 387
Sparidæ, 367
Spatula clypeata (Linn.), 328
Sphærium sp., **101**, 436, 440
Sphecina, 413
Sphegidæ, 404, 413
Sphenophorous (*see* Rhabdocnemis)
Sphingidæ, 420, 421
Sphinx (*see* Protoparce)
Sphinx convolvuli Linn., **98**, 398, 421
Sphyræna helleri Jenkins, **92**, 366
Sphyræna snodgrassi Jenkins, 349
Sphyrænidæ, 353
Sphyrna zygæna Linn., **86**, 340, 346
Spodoptera, 422
exigua (Hub.), 396
mauritia Boisd., 306, 388, 396
Spondias dulcis Forst., **70**, 264, 266
Sporobolus Virginicus Kth., **51**, 192
Squalus mitsukurii Jord. & Snyder, **86**, 340, 346, 349
Staphylinidæ, 416
Stegomyia fasciata (Fab.) = Stegomyia calopus (Meigen), 387
scutellaris (Walk.), 387
Stenogyridæ, 439
Stenolaphrum Americanum Schrank, 208, 286
Sterna fuliginosa Gmel., **78**, 310, 312
Sterna lunata (Peale), **78**, 310, 318
Stethojulis, 359
axillaris (Quoy & Gaim.), **92**, 366, 349
sp., 359
Stepanaria sp., **112**, 488

Stichopus tropicalis Fisher, 495
Stoasdon narinari (Euphrasen), **86**, 340, 347
Stomoxys calcitrans (Linn.), 387
Subemarginula oblonga Pease, 466
Succinea, 438
sp., **103**, 448
Succineidæ, 438
Sula cyanops Sund., **78**, 310
piscator (Linn.), **78**, 310
Sus sp., 295
Straussia Kaduana Gray, **61**, 220
Mariniana Gray, **56**, 202
spp., 227
Strombidæ, 457
Strombus, 447
hellii Rous., 457
maculatus Nutt., **106**, 470, 457
samar Dillw., 457
Stylasteridæ, 481
Sympetrum blackburni (McLachl.), **97**, 392, 425
Styphelia (*see* Cyathodes)
Syngnathidæ, 365
Synodontidæ, 359
Synodus varius (Lacep.), **87**, 344, 359
Syrphidæ, 419
Syzygium (*see also* Eugenia)
Syzygium = (Eugenia) Sandwicensis Gray, **61**, 220

T

Talitridæ, 409
Tamarindus Indica Linn., 245
Tecca pinnalifida Forst., 284
Teleonemia lantanæ Dist., 385, 426
Telespiza cantans Wilson, 314
Tellina dispar Conrad, **104**, 456, 445
rugosa Born., **104**, 456, 445
Tenebrionidæ, 418
Tenebroides muritanicus (Linn.), 395, 405
Tenodera sinensis, 429
Tephrosia piscatoria Pers., 207
Terebra aciculina Rve., **105**, 460, 455
cancellata Quoy, 455
crenulata Linn., 455
gouldi Desh., **105**, 460, 455
maculata Linn., 455
oculata Lam., **105**, 460, 455
sp., **105**, 460
Terebratula sanguinea Chem., 483
Terebrantia, 412
Terebridæ, 455
Teredo, **113**, 490
Terminalia catappa Linn., 245
Termitidæ, 424, 425
Terricolæ, 440
Testudo sp., 300
Tetranychus sp., 401
Tetraodon hispidus Linn., 367
Tetraodontidæ, 367
Tetraplasandra meiandra Hbd., **62**, 224
Tettigoniidæ, 427
Thala, 451
Thalamita integra Dana, **108**, 474
Thalassoma duperrey (Quon & Gaimard), 349
sp., 359
umbrostigma (Ruppell), **93**, 370
Thecla=(Lycæna) sp., 385
agra Hewiston, 385
echion Linn., 385
Thespesia populnea Corr., 201
Theveta neriifolia Jess., 252
Thumbergia laurifolia Lindl., **68**, 250
Thysanoptera, 427
Thysanura, 403, 430
Tinea pellionella (Linn.), 405, 423
Tineidæ, 423
Tinguidæ, 426
Torinia, 463
variegata Gmel., **106**, 470, 463
Tornatellinidæ, 439
Touchardia latifolia Gaud., **56**, 202, **217**
Toxoptera aurantiæ Koch, 390
Trachinocephalus myops (Forster), **87**, 344, 349, 353, 359
Trachurops crumenophthalma (Bloch), **91**, 362, 349
Tramea, 425
lacerata Hagen, 424
Trapa bicornis=**Trapa natans** Linn., 285
Trapezia cymodoce intermedia Miers, **110**, 482
digitalis (Latreille), **110**, 482
Trachurops crumenopthalma (Bloch), **349**
Tribolium ferrugineum (Fabr.), 395, **405**, 418
Tribulus cistoides Linn., **51**, 192, 199
Trichomanes davallioides Gaud., **63**, 228
Trifolium, 286
Triton, 449
pilearis Linn., **105**, 460, 450
tritonis Linn., 449
tuberosus Lam., **105**, 460, 450
Tritonidæ, 449
Trivia, 459
Trochalopterum canorum Linn., 308
Trochidæ, 466
Trochus, 463
sandwicensis Soul., **105**, 460, 466
sp., **106**, 470, 466
Trypetidæ, 420
Tunicate, **113**, 490, 116, 484
Turbellaria, 497
Turbinidæ, 466
Turbo, 466
apex fulva (Dixon), 431
chrysostomus Linn., **105**, 460, 466
intercostalis Menke, **105**, 460
Turbonellidæ, 463
Turricula, 451
Turtur (Spilopelia) chinensis (Scop.), **305**
Tylosurus giganteus (Schlegel), 349

U

Urticaceæ, 245

V

Vaccinium reticulatum Smith, **69**, 258, 225, 256
penduliformis var. Gaud., **61**, 220
Vanessa atlanta Linn., 421
tammeamea Esch., **97**, 392, 421
Vellela pacifica, 483
Venus, 446
reticulata Linn., **104**, 456, 446
Verbena Bonariensis Linn., 205
Vermetidæ, 462
Vermetus sp., **105**, 460
Veronicella sp., 439
Vespidæ, 404, 414
Vestiaria coccinea Forster, **84**, 334, 329, 440
Vexilla, 449
vexillum Chem., **106**, 470
Vinca rosea Linn., **68**, 250, 207, 254
Viridonia sagittirostris Roths., **83**, 332, 335
Viscum articulatum Brum., **59**, 214, 225
Vitex trifolia Linn., 199
Vitis spp., 267
Viviparidæ, 438
Viviparus chinensis Gray, **101**, 436, 438
Volucella obesa (Fabr.), **99**, 406

W

Waltheria Americana Linn., **51**, 192
Washingtonia filifera Wendl., **67**, 246, 237
Wikstrœmia spp., 227

X

Xanthias canaliculatus Rathbun, **110**, 482
Xanthium strumarium Linn., **53**, 196, 287
Xiphias gladius Linn., **92**, 366, 349, 373
Xiphidium fuscatum = **Xiphidium Varipenne** SW., 388
varipenne SW., **97**, 392, 429
Xiphiidæ, 373
Xyletobius, 418
Xylocopa braziliensis Linn., **99**, 406, 403, 415
Xystrocera globosa (Olivier), **99**, 406

Z

Zamia sp., **67**, 246
Zanclidæ, 361
Zanculus canescens (Linn.), **93**, 370
Zelus peregrinus Kirkl.=**Zelus renardi Kol.**, 402.
renardi Kol., **98**, 398, 426
Zingiber, 257
officinale Linn., 215
Zerumbet Rosc., **56**, 202, 221, 213
Zizania aquatica Linn., 277
Zonitidæ, 439

INDEX.

GLOSSORY AND COMPENDIUM.

NOTE.—The black-faced numbers indicate that the subject is illustrated upon the page cited. In such cases the subject may be referred to only in the explanation of the plate, or it may also be referred to in the text. Scientific names used in the text have been segregated and appear as an INDEX to SCIENTIFIC NAMES. Vernacular names in English are entered twice as Crow, Hawaiian, and Hawaiian Crow; Hawaiian names are entered but once. The work is so fully indexed that it will serve as a synonomy of the common names in current use. Frequently, where Hawaiian and English names are given as Alae (Hawaiian gallinule), both names should be consulted for additional information on the species. The important subjects treated are indexed very fully with the object of rendering the volume useful to teachers and students as a collateral reference book. Notes, explanation of terms, etc., appear in small type, and are alphabetically arranged, usually without reference to the text.

A

A-a (Rough lava), **162**, 349
and pahoehoe shown, **162**
flows on Mauna Loa, 155
Huge block of, **160**

A-a, O-o=Oo-aa, **337**

Aahumamo. A yellow feather robe worn by the king or high chief.

Aahuula. A royal cloak usually adorned with red feathers.

Aaka. A name given to the dry wood of the bastard sandalwood (*Myoporum sandwicense* Gray). When dry this wood becomes very fragrant and when burned gives off the odor of sandalwood, hence the name. The living tree is known as Naio, which *see*. The wood is very durable and was much used for house posts.

Aama, 469

A'awa, 359

"Ababai" (*see* Papaya)

Abbreviations—sp.=species; spp.=two or more species belonging to the same genus; sp. indt.=an undetermined species; = the same as; = when following a scientific name and before a locality—of or from.

Abdomen of insects, etc., (409). The hind body; the posterior one of the three parts of a perfect insect.

Aboral and oral view of Sea-urchin. **496**

Abortion was commonly practiced among the ancient Hawaiians and was accomplished in various ways, as by the use of sharp pointed bamboo instruments, jumping, etc.

Abutilon (*see* Mao)

Acacia, Species of, 205

Accidental. Said of a species that only occasionally occurs in the islands and is not considered as an established species. (*See also* occasional visitors.)

Accidental visitors [Birds] (*see* Rare birds)

Achatinella (Achatinellastrum) varia, **432**
(Achatenallastrum *error*)

Achatinelidæ [Tree shells], 434
Color variation in, **432**

Acknowledgments, General, 11
Specific, 12

Acorn barnacles, 468
shells, 473

Active volcanoes, Kilauea, 164
Mauna Loa, 183

Activities, Volcanic, tabulated, 183

Adductor muscles defined, 444

Adjustment of population to food supply, 45

Adzes, how made, 75
Sizes of, 75
Stone, 75

Aeae=Koae

Ægle (*see* Bhel)

Aëolian deposits at Mana, 108

Aërial roots (204). Those that strike from the stem in the open air.

Aërial roots, Examples of, 204, 211
Banian, **246**, 245

Affinities, Racial, of the Hawaiians, 25
with other Polynesians, 25

Africa, 208, 213, 245, 269, 279, 285, 386, 388, 397 407

African mole-cricket 388

Agassiz, Louis (Geologist, Naturalist), 94

Age of Hawaiians. The census of 1896 brought to light several Hawaiians who were then 110 years of age. The well authenticated case of Kepoolele Apau was investigated by Hon. Alatau Atkinson and the patriarch was examined by Dr. W. D. Alexander and Mrs. Emma M. Nakuina. Mrs. Apau was then 124 years old. She was born in Puna, on Hawaii.

Age of Kohala Mts. shown by erosion, [Waipio], **154**
of Oahu, 117

Aged kahuna, 52

Agriculture (cattle raising), **282**
Effects of on plants and animals, 269
Enemies of, 381
Growing cane, **278**
Hawaiian, 63
in recent times, 269
Rice growing, **270**
Taro growing, **270**

Agricultural industries, Minor, **270**
industries (Growing sugar-cane), **274**

Alia. A cord braided from the husk of cocoanut, or from human hair; or strings made from the intestines of animals.

Ahaaha (Needle-fish), **350**, 349, 364

Aha-aina (feast), 355

Ahakea. Name of a species of yellowish wood (*Bobea* spp.) used for rims of canoes, poi boards and paddles. The tree in the forest is conspicuous by reason of its light green foliage.

Aha-moa. The name of an assembly collected at a cock-fight.

Ahanui, **206, 224**
Ahi, 349, 361
Ahinahina (Silver-sword), **206,** 229
Aholahola, 341
Aholehole (Sea-perch), **336,** 349, 358
Ahuhu, 207, 227, 341
  similar to digitalis, 207
  Uses of, 207
Ahuula (Feather cape), **48, 70**
  of feathers, **44**
Aiea=Kaawau
Aiea, Mill at, **274**
Ainahau Garden, **234**
  Lily pond in, **234**
Air breathing mollusks, 434
Air-plant, **240,** 208, 254
  peculiarity of, 208
Akaakai (Bullrush), **198,** 199.
Akai, 227

Akai. Name applied to the different species of the genus *Wikstroemia*. The shrubby plants have a tough bark furnishing a strong native fiber and contain an intoxicating narcotic which was employed by the natives to poison fish in fresh water as auhuhu was used in salt water.

Akailoa, Kauai, **330**
Akala, 256
Akala Falls, 176
Akepe, 333
Akialoa, **330**
Akikihi, **337**
Akilolo, 359
Akoakoa=general name for coral, **486**
Akoko, **192, 212, 220,** 283
Aku (Ocean bonito), **366,** 349
  and Opelu tabu (*see* Opelu)
Akule (Big-eyed scad), **362,** 341, 349, 364
Akulikuli, **192**
Akulikulikai, 199

Alaa. A name applied to the species of the genus of trees *Sideroxylon*. The sap of the more common species (*S. Sandwicense* Benth. & Hook.) was used as a bird lime.

Alaala=(Fig. 9), **482**

Alaalahee. The spawn or eggs found in the 'squid.' It was eaten, with kukui nuts as a relish.

Alaalapuloa, **192**
Alaalawainui, **202**
Alae (Hawaiian gallinule), **323**
  Legend of, 326
  keokeo (Hawaiian coot), **323**

Alahee. The name of a tree (*Plectronia odorata* Benth. & Hook.); from its wood instruments were made for tilling the soil. (*See* Oo.) The leaves were also used to produce a black dye. A shrub or small tree with glossy leaves and fragrant, sweet-scented flowers common on all islands, but especially on Molokai.

Alaihi, 371
Alala (Hawaiian crow), **327**
Alalaua (Catalufa), **366**
Alamihi, 466

Alaneo. The name of a cloak, or royal robe, made of the feathers of the mamo only.

Alani, **220**
Alaska, 324
Alauhiio, **332**
Albatross, 312
  Black-footed, **310**
  Black-footed, following a steamer, **316**
  care of young, 315
  "dance," **316,** 314
  eggs, **316**
  eggs, Use of, **316**
  Laysan, **92, 294, 316**
Albatross, U. S. Fish Com. ship, 351 (frequent mention in subsequent pages)
Albinism, Examples of (*see* Sparrows)
Alcyonarians, 479
Aleihi lakea, 349
Alena, **192**
Alexander, Dr. William D., (Historian), **12**
Alfalfa, 286
Algæ, 500
  Common, at Waikiki, **492**
  Edible, 502
  from the reef, **498**
  How to collect, 500
  Literature on, 502
  on the summit of Mauna Kea, 152
Algaroba, 208, 242
  habitat of, 243
  bean weevel, 395
  gum, 243
  honey, 243
  pod weevel, 395
  Phylodendron in an, **240**
  scale, 391
  tree [Kiawe], **240**
  trees at Waikiki, **116**
  uses of, 243
  when introduced, 242
Alkali feldspar lava, 155

Alii. One who rules or has authority over men.

Aalii or Alii. The name of a small hard wood tree (*Dodonæa viscosa Linn.*) common on all islands up to the 4000 foot level. The wood is used to some extent for fence posts; the leaves were used for medicine by the natives.

Alii (Chiefess), **60**
  how buried, **52**

Alii kapu. The high chiefs were styled alii kapu or sacred chiefs and almost divine honors was paid to them.

Aliipoe, 207
Allamanda, 248, 252
Alligator pear=Avocado pear, **258,** 261
  (*see also* Avocado), 262
Alluvial plain, Examples of [Hanalei], **106**
Almond, Demerara, 245
  nuts of, 248
  Tropical, 245
Alphabet, The Hawaiian, 39
Alps, 229
Altars, Fishermen's, 339

Alteration of generations, Example of, 391
explained, 390
Alternate (208). Leaves placed one after another; but one leaf growing out from each joint of the stem.
Ama (the outrigger), **80**
Amaama (Mullet), **362**, 349, 359
Amakaha, 368
Amakihi, 329
Kauai, **334**
Maui, **332**
Amakuas, 49
Thorny, **196**
Amastridæ (Ground shells), 434
Amaumau, **228**, 222
Ama'uama'u=[amaumau] which *see*.
Amber colored ivory, how made, 79
Fish [Kahala], **362**, 365
Ambergris, 302
Ambulacral zones explained, 485
America, 293, 297, 325, 376, 394, 397, 410, 422, 428, 249, 252, 254, 286
American, 303, 336, 402
cockroach, 402
continent, 191, 242, 262, 268, 280, 284
lobster, 468
toad, **384**
Amaranth, Common, **196**
Ampullæ explained, 489
Amusements at Waikiki, **80**
Hawaiian ,74
The hula, etc., 81
surf riding, **80**
Anacardium (*see* Cashew nut)
Anal fin (364). The fin on the lower side of a fish just in front of the tail fin.
Anapanapa 204
Anchorages (*see* Harbor anchorage)
Anchovie [Nehu] **350** 351
Ancient voyages, 27
wooden idol, **52**
Anemonies attached to crabs, 476
Sea, **490**
Andes, 229
Angelica, 253
Angoumois grain moth, 405
Anklets, **78**, 82
Animals and plants brought to Hawaii, 27
dyes, 69
industry in Hawaii, 287
life, Effects of agriculture on, 269
as gods, 49
Domestic, 287
from the coral reef (part one), 468
from the coral reef (part two), 485
from land and sea, 291
Hawaiian marine, **294**
Introduced, 231, 295
Native, 295
to be collected at Waikiki,**116**
Annual plant (276). Flowering and fruiting the year it is raised from seed; then dying.
Annual yield of sugar, 271
Anona, 266
Anomia 445
nobilis (young,) **456**
Antarctic, 229
Antennæ (407). Organs occurring in pairs on the head of insects, crabs, etc., and serving as feelers or tentacles. They vary greatly in size, shape and function.
Anthicids, 418
Ants, 387, 403
Ants, bees and wasps, 403, 412
Ant-lion, 425
Ant, native, 413
poison, 403
White, 402
Anvil, Tapa, **64**
Ao=*Puffinus newelli* Henshaw,
Apahu (Headfish), **374**, 358
Apapane, Hawaiian, **334**, **337**, 329
Laysan, 320
Use of feathers of, 77
Ape, 225
Apeape, **194**, 225
Apekepeke (Kauai elepaio), **334**
Aperature (447). An opening; hence the mouth of a gasteropod shell.
Aphids, 265, 389, 425, 427
on, 389, 390, 391
Apii, 225
Appearance of Honolulu, 231
Apple banana, 259
Custard, 266
Mountain, 256
Rose, 267
Tahiti [Wi], **264**, 266
Apples, 267
Apuu-u, 364
Aquatic beetles, 416
bugs, 426
Aquarium, Fish at the **356**
Honolulu, 348, 354, 359, 360, 367, 368, 375
Octopus at the, **442**
View of, **356**
Arabia, 379
Arabian cowry, 459
jasmine, 248
Aralia, 253
Araucaria, 237
Arbor (201). A bower formed by trees, shrubs or vines usually trained over a lattice work to form a shelter from the sun.
Arboreal (245). Tree like; the size and shape of a tree.
Arch, Onomea, **150**
Archæolithothamnium sp. (**fig. 4**) **398**
Archipelago, Development of Hawaiian, **290**
Arctic, 301
right whale, 301
Area of various islands (*see* Length, etc.)
Argyreia (*see* Pilikai)
Ark shell, **456**, 444
Aristotle's lantern, **496**, 485
Armadillo-bugs, 408
Arm of a starfish, **496**
Armor, Hawaiian, 79
Army stores, 51
worms, 396
Arrangement of text explained, 10

Arrow-root, Hawaiian, 284
Artesian springs, 127
wells, 127
Cause of brackish, 127
Evidence from, 220
First, 127
how formed, 127
Number of 127
Arthropods, 409
Artocarpus (*see* Jack fruit)
Arts, Hawaiian, 74
Ascent of Haleakala, 143
Kilauea, 176
Mauna Kea, 151
Mauna Loa, 155
Ash eruption from Diamond Head, 121
Punchbowl, 121
Tantalus, 121
Ashmead, Dr. W. H. (Entomologist), 413
Asia, 235, 245, 257, 267, 269, 285, 286, 397
Asiatic, 191, 225
Assam, 283
rubber, 283
Assassin bug, 402, 426
Astringent (217). A substance which binds or contracts the tissues and canals of the body.
Astrologer 51
Astronomy, Knowledge of, 30
Atlantic, 346, 358
Atoll, Example of, 94
Attack, Methods of, 51
Au. The handle or helve of an ax. They were often made of hau wood.
A'u (Swordfish), **366**, 373
Auamo. The stick or pole used to carry burdens when balanced across the shoulder. *See* plate 12.
Auamo (Carrying stick), **57, 68**
Auau. The stalk of loulu (*Prichardia* spp.) made into a spear.
Auger shells, 455
shells used for, 455
Auhola=Auholo
Auholo, 207
Auhuhu=Ahuhu
Aukuu kohili (Black-crowned night heron), **310**
Aulima. The name of the stick held in the hand when rubbing to produce fire. The name of the stick rubbed is *aunaki*. The action of rubbing is *hia*.
Aunaki (*see* Aulima)
Australia, 191, 213, 320, 381, 386, 402, 410, 429
Australian cockroach, 402
grasshopper, 429
ladybird beetles, **384**
ladybirds introduced into Hawaii, **384**
mantis, 429
oak, 248
Author, Photographs by the, 14
Portrait of (*see* Frontispiece), **4**
Autochthonous (*see* Endemic)
Averrhoa (*see* Carambola)
Avocado, 261
or Alligator pear, **258**
(*see also* Alligator pear), 262
Introduction of, 262
mealy-bug, 391
Names for, 262
not injured by fruit-fly, **262**
Propagation of, 262
scale, 391
Yield of, 262
Awa, 67, 216, 227, 236, 249
(Milk-fish), **350, 360**
-aua, 360
-awa=awa-aua
How made, 216, 217
Awa drinking. The root of the awa plant produces a numbing effect on the mucus membrane of the tongue, and is thought to allay thirst by its pleasant aromatic flavor. The Hawaiians recognize six or seven varieties of awa all of which are regarded by botanists as forms of the one species. Awa from Puna, Hawaii, was considered of the best quality. In former times the drink was used almost exclusively by the chiefs. Later, it came to be a prevalent habit among old natives, and awa drinking is still quite common throughout the group in native settlements. The object of drinking is primarily to produce stupification. The drink is made from either the fresh or dry roots. The regular drink was one cup full from a cocoanut cup, cut lengthwise of the nut. The plant is an upland growth and is found where the ground is both damp and shady. It was, and is, planted by the natives in suitable localities. The ground is loosened and a joint or cutting set in, after the native method of planting sugar-cane. After a time it is hilled and left to grow without further care. It continues to grow and spread its roots abroad. Roots 20 years old are enormous in size—sometimes being all two or three men can carry. *See* awa.
Awapuhi (Native ginger), **202, 215**
Use of, 215, 221
Awikiwiki. Name of a leguminous vine (*Canavalia galeata* Gaud.) common on all islands. According to Andrews the "berries" were used as a medicine, operating as an emetic and cathartic. The species bears 4 to 8 large seeds in a pod.
Awela, 359
Aweoweo, 349, 354
Axes (*see* Adzes)
Axillary (Bot.). Occurring in the axils; i. e., in the angle on the upper side between the stem and the leaf.
Axis deer, 296

B

Back-scratcher, 62
-swimmers, 426
Bacilus, Plague, 401
Bael (*see* Bhel)
Bagasse, 275
Bag-nets, 341
Baked taro, 67
Baked pig [puaa], Dish for, **70**
Baker, R. J., Photographs by, 14
Bakery beetles, 405
Baking in the imu, 66
Bait, Fish, 242, 339
Human flesh as, 343
seins, 339
Balanoglossus, 484

Baldwin, Prof. Charles W., (Geographer), 12
Photographs by, 14
Baldwin, Mr. E. D., 163
Balistes, 375
Bamboo (or Bambu) aphis, 391
beetles, 405, 418
rattles, 82
Use of, 82
Banana(s), 67, 207, 248, 255
as a fiber plant, 280
aphis, 389
Apple, 259
Bluefield, 259
Brazilian, 259
business, Development of, 261
Carious flowers of, 260
Cavendish, 259
Chinese, 258, 259
introduced from, 260
Cooking, 259
Cultivated, 257
Diseases of, 260
Dried, 260
Eating, 259
flour, 260
Home of, 257
Jamaica, 259
Kusaie, 259
Largo, 259
leaf-roller, 395
leaves, Uses of, 66
Martinique, 259
Native varieties of, 259
Nomenclature of, 259
Pests of, 260
Propagation of, 260
Rose, 259
Seed of, 260
Sweet scented, 259
Varieties of wild, 222
Wild, 190
yield per acre, 260
Banded bubble-shell, 467
Banian, 245
Aërial roots of, 245
Bengal, 245
-fig, 283
Number of species of, 245
Rubber producing, 283
Sacred, 240
tree, 246
Banner shell, 470
Banyan (*see* Banian), 245
Barbados cherry (*Malpighia glabra* Linn.). A well established, though not a common fruit in Honolulu gardens, coming originally from the West Indies. It is a small bushy shrub with dull green, opposite, ovate leaves. The rose-colored, five-parted flowers spring from the axils at the base of the leaves; they are followed by a cherry-sized, rich, red fruit, with acid pulp surrounding a hard seed. The fruit may be used for jam and preserves.
Barbadoes, Pride of the, 244
Barbels [fish] (372). A small, slender, elongated process appended to the mouth of certain fishes (Barbules *error*).
Barber's Point, 109
Bark cloth clothing, 38
lice, 391
rope, 201
Barking sands, 108
sands, Makua station, 122
Barnacles, 473
Acorn ,473
Coronet, 475
from the sea-shore, 474
Goose, 473
Sessel, 473
Stalked, 473
Barnard, E. W., 299
Barracuda [Kawalea], 366, 351
Barrier reef at Midway, 94
Barter (*see* Hawaiian markets)
Basalt. The term basalt is used, in a somewhat comprehensive way, for dark compact igneous rocks that appear to be nearly homogeneous owing to the smallness of the crystals which are usually so minute as to be identified only under the microscope. There is usually a considerable range in chemical composition, but the basalts are relatively poor in silica, but rich in lime, magnesia and iron. They are classed as basic rocks and are sometimes highly so. *See* Hawaiian Igneous Rocks.
Basalt as building stone, 129
Columnar, 109
Basaltic craters, Small, 115
Base of the columella (453). Applied to the extreme lower portion of the inner wall of the shell which surrounds the axis.
Bases of Hawaiian mountains, 155
Baskets, Fish, 70
Pandanus, 70
stars, 491
Bas-relief groups (Kamehameha I. statue) described, 44
Bass, Black, 377
Bast (fibers), 22
Bastard sandalwood, 210, 222, 226
Batavia, 279
Bath rubbers, 63
Bathing beach at Waikiki, 116
Baths, Hawaiian medical, 79
Bats, 295
Battle(s), Naval and land, 51
Notice of sent, 51
Preliminary to a, 51
Women in time of, 46
Bays, Harbors, Landings, etc. ON OAHU—Honolulu Harbor, Pearl Locks, Kaneohe Bay, Waialua Bay, Kahana Bay. ON HAWAII—Hilo Bay, Kealakekua Bay, Kawaihae Bay, Kailua Bay, Mahukona, Laupahoehoe, Honuapo, Hoopuloa, Napoopoo, Keauhou; ON MAUI—Kahului, Maalaea, Hana Bay, Keanae, Nahiku, Kipahulu, Kaupo, Makena, McGregor's Ldg., Olowalu, Lahaina, Kaanapali (Kekaa), Honolua; ON KAUAI—Hanalei Bay, Hanamaulu Bay, Nawiliwili Bay, Ahukini, Kapaa, Anahola, Kilauea, Waiuiha, Koloa, Eleele, Hanapepe, Makaweli, Waimea, Port Allen; ON MOLOKAI—Kaunakakai, Kamalo, Pukoo, Halawa, Wailau, Pelekuna, Kalaupapa.
Bay, Kahana (Oahu), 128
Waimea (Oahu), 128

Bays on Hawaii, **148**
on Kauai, **104**
on Maui, **134**
On Oahu, **110**
Beach at Hilo, **352**
grass, **192**
heliotrope, **192**, 199
morning-glory [Pohuehue], **192, 218**
sand, use of, 129
-worm shells, 441
sandalwood [Iliahi], **192**, 199
Beaches, Olivene sand, 129
Beak of the swordfish, 373
Bean leaf-roller, 395
weevils, 405, 418
Beater, Tapa, **70**
Beaumontia, **250**
Beaver, Sea, **496**
Bedbugs, 402
Beddard, F. E., (Zoölogist), 440
Beds, Sulphur, at Kilauea, **170**
Beefwood, 237
Beer, Hawaiian, 210
Bee(s), 412
Carpenter, 403
Common, **406**
feeding on Palm blossoms, 232
Honey, 404
Leaf-cutting, 415
Long-tongued, 415
Solitary, 415
Wad-cutting, 415
"Beestill-tree," 252
Beetle(s), 395, 405, 415
Australian ladybird, **384**
Common, **406**
Japanese, Enemies of, **384**, 394
Japanese, on grape, 267
Ladybird, 393
on sugar-cane, 388
-roach, 388
Salt marsh, 418
Water, **436**
Belgian hare, 293
Bell-shaped animals, 480
Beneficial birds, Introduction of, 308
Bengal banian, 245
Bermuda grass, 286
Berry (Berries), Christmas, 225
Coffee, **270**
Japanese raspberry (Thimble berry), **258**
Ohelo, **258**, 256
Thimble, **258**
Betel nut, 236
Use by South Pacific islanders, 236
Betrothal, 43, 45
Betting (*see* Gambling)
among Hawaiians, 86
Bhel or Bael fruit (Ægle sp.). This small, strongly-spinose tree with alternate tri-foliate leaves is not uncommon in Honolulu gardens. It is distinguished from the nearly related *Citrus* genus by the hard gourd-like rind of its fruits which, when ripe, is yellowish-brown and 3—4 inches in diameter.
Big-headed ant, 403
"Big-eye" (Fish), 354
Big-eyed flies, 419
scad [Akule], **362**
Bignonia, 248
Biologist (385). One skilled in or a student of the science of life and living things, in the widest sense.
Bird-catchers were an important class in old Hawaii who captured birds for their feathers. In addition to several well-known bird-limes (which *see*), they employed nets and spears. They recognized two seasons for catching birds: one from March to May, the other from August to October. These correspond with the flowering season of the ohia lehua. The trees in the lower woods flower in the spring; those higher up in the fall season. The birds they sought move from place to place, wherever flowers and food is plentiful. The bird-catcher of former times said prayers and made offerings to his gods that the birds of the forest might be gathered into his gum-traps and held fast. It is reported that Kamehameha I was the first to appreciate the importance of protecting the birds. He reproved his bird hunters for taking the lives of birds they caught.
Bird-claw vine, **250**, 248
Bird colony at Laysan, Large, **92**, 95
feathers, Source of, 98
Fishing (Heron), 325
flies (Louse-flies), 421
groups in Bishop Museum, **310**
Island [*see* Nihoa] (volcanic), **88, 96,** 98
-lice, Wingless, 400, 430
life on Laysan, Views of, **310, 316**
Bird lime, 226
Bird-lime was usually made from the juice of certain Lobelias. Breadfruit gum was also used, as was the juice of the species of papala (*Pisonia* spp.). Oha (*Clermontia* sp.) was perhaps the best source of gum. The gum of the last two was prepared by boiling.
Bird, Man-o'-war, **310**
Miller, and nest, **316**
notes (*see* species in question), 331
pirates, 318
poachers on Lisiansky Island, 95
poachers on Midway Island, 94
Red-headed alae, 328
reservation, Hawaiian Islands, 93
songs (*see* species in question), 331
White-headed alae, 328
Accidental visitors (*see* Rare birds), **310**
Birds as food (*see* species in question), 311
Birds as pets. It was quite the custom with bird catchers to keep the o-o, iiwi and apapane alive in special cages to use as decoys in bird catching. They were feed, daily, on the nectar of their favorite flower and in time became very tame.
Birds as ocean waifs, 308
as regular visitors, 308
Beneficial, introduction of, 308
Capture of, at night, 311
Cliff-nesting species, 311
Finch-like, Hawaiian, 331
Hawaiian, Peculiar odor of, 331
Identification of sea, 309
Introduced, 304
of Laysan Island, 312
of the marshes, 320
of the mountain forests, **334**, 328

of the mountain forests, Some rare and extinct, **332**
of the ocean islands, 308
of the sea, 308
of the shore, 320
of the streams, 320
Native, **332**
Night flying, 304
Occasional visitors, 308
Rare and extinct, **332**
Rice, 277
Some rare and extinct, **330**
Various orders of, **323**
Weaver, 277
Winter visitors, 308
Bird's nest fern [Ekaha], **190, 240,** 223
Natural habitat of, **190**
Bishop Museum, Bird groups in, **310**
Mention of, 98, 173, 176, 188, 223, 291, 299, 302, 304, 348, 435, 455
Objects deposited in, **57**
Spern whale in the, **298**
Bishop, Dr. Sereno E., (Geologist), 98, 115, 120, 124
Bite of centipede, 405
Bivalves, 443
defined, 443
Common marine, **456**
Black bass, 377
Introduction of, 378
Black blight, 386
Blackburn's butterfly, 421
Black-crowned night heron, 325
Black cutworm, 396, 422
-eyed susans, 207
-eyed susans, Uses of, 207
fly, 265
-footed Albatross, **310,** 312, 315
mamo [Hoi], **332,** 335
-mouthed tun, 461
mulberry, 267
rat, 291
rock crab, 469
sand, 117
scale, 391
slug, 439
Point, Spouting horn at, 131
wasps, 414
wattle, 248
Blennie, **374,** 353
Blight, Black, 386
Maui, **384,** 385
on the mango, 242
Block of a-a, Huge, **160**
Blossoms of (*see* plant in question)
from Honolulu gardens, **250**
of sugar-cane, **278**
Blow-hole (*see* Spouting horn), 108, 131
Specimen of a, **184**
Blubber (302). The fat of whales from which a fine oil is obtained. The blubber lies under the skin and covers the muscles.
"Blubber," Whale ship stripping off, **298**
Bluebottle fly, 387, 419
"Blue bottles," 481
Blue butterfly, 421
dragon-fly, Big, 424
leadwort, 254
palm, 237
parrot fish, **370,** 365
shark, **340**
-faced booby, **310, 316**
Bluefield banana, when introduced, 259
Board, Poi, 66
Surf, **80**
Boar's tusks, 79
Use of, 77
Boatman, Water, **436**
Bohea spp. (*see* Ahakea)
Bodies, how disposed of, 52
Body louse, 400
Body whorl (452). The last and usually the largest whorl or turn of a shell, ending in the aperture.
Bog flora, **218**
on Waialeale, 105
on West Maui, 138
Boilers, Sugar (Evaporating pans), **274**
Boki, Governor, 279
Boll worm, Cotton, 281, 399
Bombs (*see* Volcanic bombs)
Bone, Implements of, 74
meal beetles, 405
stone and wood, Uses of, 75
Use of, 63, 73
Bone-fish [Oio], **350,** 354
Bone fishhooks, 242
Bones, Concealment of (*see* plate 8)
Human, use of, 77
Bonin petrel, **323, 360,** 312
Bonine, R. K., Photographs by, 14
Bonito, California, 363
Fishing for, 363
Little, **366**
Ocean, Catching, **344, 366,** 361
Bony fishes (351). Fishes with bony instead of cartifaginous skeletons. Sharks, rays, etc., are examples of the latter class.
Booby, Blue-faced, **310, 316**
Red-footed, **310, 316**
Boobies, 314
robbed by, 317
Book, Contents of Book One, 15 to 19
Contents of Book Two, 19 to 22
-lice, 424, 425
-worm beetle, 418
Borer, Sugar-cane, **380,** 383
Boring ants (termites), 402
Hymenoptera. 412
Boston fern, 253
Bottle gourd, Use of, 61, 209
Palm, **240,** 237
'Bottomless' pit on Haleakala, 146
pit on Hualalai, 152
Bougainville, Louis Antoine de (Navigator), 248
Bougainvillea in bloom, **240**
named for, 248
Varieties of, 248
Boulders, Field (Oahu), **130**
Bowling alley, Primative, 83
stones [ulu-maika], **57**
Bowls and dishes, 59
Finger, **70**

Bow and arrow, 81
made of, 215
not used in warfare, 81
Use of, 293
Box-fish, 375
Boxing [mokomoko]
the national game, 83
Bracelets of shells, 79, 465
Brachiopods, 483
Brackish artesian wells, Cause of, 127
Brackish water crab, **436**
fish, 358
fish (gobies), 357
shells, 439
Bracts (201). The small leaf or scale from the axil of which the flower or its stem proceeds.
Braided hair ornament, **60**
Brain corals, 479
Brake, Common, 223
Branching coral, **486, 488**
Brazil, 257, 262, 267, 268, 283, 285
Brazilian banana, 259
Brazilian plum (*Eugenia Brasiliensis* Lam.) or Spanish cherry is widely known as the grumichama of Brazil. It was probably first introduced by Don Marin, but fine trees may be seen in the garden of Mrs. Mary E. Foster, introduced by Dr. Hillebrand. The deep purple fruit is the size of a cherry; the leaves are oval or obovate 3 inches long by 1½ broad and occur scale-like along the branches. The edible fruit has a very agreeable flavor.
Breadfruit [Ulu], **258, 264,** 239, 241
how cooked, 67
how propagated, 67, 241
groves, old, 138
stems, Use of, 71
Uses of, 241
Wood of the, 241
Breaker, Canoe, 81
Breakers at Laysan Island, **92**
on Oahu, **122**
Breccia. A rock composed of angular fragments cemented together by nature. It is to be compared with conglomerate in which the fragments are rounded.
Breccia at Diamond Head, 219
Calcarious, 121
Breeding cages, Entomologist insect, **380**
Brick, 127
Lava, 129
Brigham, Dr. W. T. (Museum Director), 155
Bristletails, 403, 430
Bristle-thighed curlew [Kioea], **310, 316,** 325
Bristle-worms, 497
Brittle starfish, **496,** 485, 487, 489
Broken bones, how treated by old natives, 197
Brooks, Capt., 94
Broom, Hawaiian, **76,** 62
Brown house-spider, 409
ant, Big, 403
grasshopper, 429
mountain cricket, 429
rat, 291
'Brownie' ladybird, 394
Bryan, Dr. Elizabeth Letson, (Conchologist), 12
Bryan, W. A., Photographs by, **14**
Bubble, Caved in (Kilauea), **186**
dome in Kilauea, **186**
Bubble-shell, **470**
Banded, 467
Bubonic plague, 292
Buffalo, Water, **282**
Bugs, Aquatic, 426
Chick- (Beetle), 417
True, 425
Sow, **436**
Bugle, Hawaiian [Pu], 449
Building material, 129
sand, 129
timber, 213
of a house, 58
stone, Basalt as, 129
Bulb (213). Usually an underground leaf-bud with fleshy scales.
Bulbs (Aërial), 213
Bull frogs, 299
Bullhead catfish, 377
Bullrush [Akaakai], **198,** 199
Bulwers petrel, **310**
"Bunn," 280
Bureau of Agriculture and Forestry (*see* Reforesting), 14
Burial cave, Hawaiian, **52**
Burr, Sand, 287
Burrows, Bird, 313
Bushes (low) on Ocean Island, **90**
Butter, Tamarind, 245
Butterflies, 421
Cabbage, **392,** 399
Butterfly-fish [Kikakapu], **370,** 353
Kamehameha, **392**
-like fishes (Scorpion), 368
By-path in Ainahau Garden, **234**
Byssus of Mytilus shown, **478**

C

Cachlot, 301
Cabbage butterfly, **392,** 399
butterfly, White, 422
tree, 210
worm, 399, 422
Cable Company, 93
Cactus, Common, 209
Cadelle beetle, 395
worm, 405
Cæcum shells, 463
Calabash (*see also* Umeke), **57, 76,** 59
Calabash gourd, **57,** 61, 67, 209
nets, 59
Introduced, 61
Use of pulp of, 79
Diameter of, 59
Calabashes, how polished, 59
of wood, How made, 59

Calcarious concretions on Maui, 139
corals, 475
sponges, 500

Caldera. The name often applied to the bowl-shaped cavity otherwise known as the crater of a volcano.

California, 262, 266, 284, 293, 295, 299, 304, 308, 345, 353, 363, 376, 377, 387, 393, 408, 445
bonito, 363
house finch, 304
lizards, 299
oysters, 445
palm, 237
partridge, 308
peanuts, 285
pepper tree, **240**, 245
Scale in, control by, 393

Calyx (257). The outer set of the floral envelope or leaves of a flower.

Cameo shells, 461
'Camp' Moomumi, **136**
Campbell, James, 126
Camphor, 262

Canal [Mollusca] (447). When the aperture is notched or produced to receive a fleshy tube, the respiratory organ.

Canary, Laysan, 314, 319, 320
Laysan, nest and eggs of, **316**
Yellow, 320
Canavalia (*see* Awikiwiki)
Cancillated auger shell, 455
Candle-nut tree ([Kukui], **202**, 239
Candolle, Alphonse Loius Pierre Pyramus de (Swedish Botanist), 235
Candy, Hawaiian, 210
Cane (*see also* Sugar-cane and Sugar)
-borer, 388
cars, **278**
fields, Rats in, 291
fields, Spiders in the, 410
loader, Patent, **278**

Canine (367). Dog-like in reference to the sharp pointed, tearing teeth of a dog.

Canna, 207, 257

Cannibalism. Dr. W. D. Alexander has asserted in his History of the Hawaiian People that cannibalism was regarded with detestation and horror. On the same subject the Rev. Sheldon Dibble, author of a much earlier History of the Sandwich Islands, states: "The practice was not common, and it is due to the Hawaiians to say that those few instances that did exist were looked upon by most of the people with horror and detestation."

Canoe [Waa], **80**
breaker, 81
Burial, **52**
Fishing, 339
house, 58
Hull of a, **80**
model, **57**
races, 86
surf riding, 86
War, **48**
Canoes, Decked, 29
Double, 29
Dimensions of large, 29
how made, 29
of koa, 211
Single, **80**
Cañon, Olokele, **102**, **106**
Waimea, **106**
Cañons on Kauai, **104**, 107
Cape Gooseberry, 257

Capes. On OAHU—Kahuku Pt., Mokapu Pt., Mokapuu Pt., Diamond Head, Barber's Pt., Kaena Pt.; on HAWAII—Upolu Pt., Kumukuahi Pt., South (Ka Lae) Pt.; on MAUI—Kahakuloa Pt., Kauiki Pt.; on KAUAI—Haena Pt.; on MOLOKAI—Kalae o Kailio, Ka Lae o ka Laau, Kapuupoi.

Capes and Points on Oahu, **110**
Feather, 77
on Hawaii, **148**
on Kauai, **104**
Captain Cook's death, Date of, **84**
Place of, **84**
Captain Cook's monument, **84**
Capt. Walker, Home of (Ship wrecked on Midway), **90**

Carambola (*Averrhoa Carambola* Linn.) has long been cultivated in the islands. It doubtless came from China or India. It may be identified most readily by its acid fruits which are about the size of a lemon, yellow in color, acutely five-angled, with a thin skin and watery pulp. The fragrant fruit is used when half grown for pickles; when ripe for preserves. The flowers are rosy purple; the tree usually 15—20 feet high, has alternate odd pinnate leaves. It is said to produce three crops a year.

Cardinal-fish, 369
Cardium, 446
Care of young (*see* species in question)

Carnivorous (357). Subsisting on animal food.

Carolinas, 345
Carp, 376
Carpenter bee, **406**, 403, 415
Carpet beetle, 395
Carrion beetles, 416
Carrying nets, 61
stick [auamo], **51**, **68**, 61
Carthagenians, 269
Carved dish, **70**
Carving, Hawaiian, 59
Stone, in caves, 129
tools of stone, 74
Case-forming moths, 423

Cashew nut (*Anacardium occidentale* Linn.). The kidney-shaped nut consisting of a kernel inside a very hard shell is borne upon a swollen pear-shaped yellow edible stalk. When roasted the kernals are also edible. The small spreading tree is a native of the West Indies, but occurs sparingly in Honolulu gardens. One of the first trees introduced was planted by Mr. Henry Davis in his garden in Punahou, Honolulu. The flowers are pink and sweet-scented: the leaves light green, oval in shape and with a rough leathery texture.

Cassava, 283, 284
Uses of, 284
Cassia, 205
flower, 205
Horse, 244
Purging, 244
Species of, 244
Cassis, 461

Castor bean, 285
bean bean-pod shells, 449
Casts, Fossil root-, 140
Root, 118
Sand, 118
Catalufa [Alalaua], 366, 354, 369
Cat-claw vine=Bird-claw vine
Caterpillar (385). Usually the larvæ of a moth or butterfly, but also applied to the same stage of development for other insects.
Caterpillars stung by wasps, 414
Catfish, 377
Cats. Cats were an early introduction into Hawaii. A breed of bob-tailed cats is common—the tail having a curious corkscrew kink at the end.
Cats, 293
cradles, 86
Cattle, effect on forest, 226
Loading, 282
Introduction of, 295
raising in Hawaii, 282
towed to steamer, 282
White-faced, 282
Wild, 295
Cavalla [Omilu], 362
Cavalla (small=papiopio, medium size=paupau, large=ulua).
Cavalla [Puakahala], 366
Cave in a lava flow on Hawaii (Rainbow falls), 160
dwelling, Abandoned, at Mooomumi, 140
Caved-in bubble (Kilauea), 186
Cavendish banana, 259
Cavengerie, 273
Cavern in Kilauea, 186
Caves, Burial, 52, 129
at Haena, 108
in Kilauea, 170
Stone carvings in, 129
Cavey, Cutlers, 293
Cayenne cherry, 267
Ceara rubber, Seeds of, peculiar, 281
rubber tree, 281
Cenozoic, 117
Centimeter (*see* Meter)
Centipede, 398, 405
Bite of, 405
Large specimens from, 407
Central America, 211, 266
Centrifugals, Sugar, 275
Century plant, 280
Cephalopods, 441
Cereus, Night-blooming, 246, 254
Night-blooming (in flower), 246
season, 254
Cerithium, 464
Certain foods forbidden to women, 46
Ceylon, 221, 296
Chamberlain, Mr. J. E., 502
Changes produced by agriculture, 271
Channels, Maui-Molokai, 134
Channels (*see* Inter-island channels)
Chapter—I, pages 25-31; II, 31-37; III, 37-47; IV, 47-56; V, 56-63; VI, 63-74; VII, 74-87; VIII, 89-99; IX, 99-109; X, 109-132; XI, 132-147; XII, 147-164; XIII, 164-183; XIV, 183-188; XV, 189-210; XVI, 210-230; XVII, 231-243; XVIII, 243-254; XIX, 255-269; XX, 269-287; XXI, 290-304; XXII, 304-308; XXIII, 308-320; XXIV, 320-328; XXV, 328-338; XXVI, 338-347; XXVII, 348-360; XXVIII, 360-375; XXIX, 376-378; XXX, 379-390; XXXI, 390-410; XXXII, 410-431; XXXIII, 431-440; XXXIV, 440-453; XXXV, 453-467; XXXVI, 468-485; XXXVII, 485-503.
Character of the native insect fauna, 411
fish fauna, 351
Character of the (*see* order family genus or species in question)
Characteristic gulch on Hawaii, 150
shore-line (Hawaii), 150
trees [Lauhala] on the shore line, 150
undershrub (Middle forest), 200
Chastity, 42
Checkered beetles, 417
Checkers, Hawaiian, 86
Cheese maggots, 405
"Cheeses," 196
Cheribon cane, 273
Cherimoya, 266
Cherry, French, 267
Ground, 257
Surinam, 267
Chest shell, 444
Chewing gum, made from, 266
Chicken louse, 400
Chickens, Wild, 295, 308
Chick-pea shells, 450
Chief food fish (Mullet), 359
industry (Cane growing), 274
magistrate, The King, 55
Chiefess [alii], 60
Chiefs and common people one race, 38
and intrigue, 55
Council of, 55
feared by common people, 55
Marriage of, 45
Powers of, 54
Rivalry among, 55
Size of the, accounted for, 39
Stature of, 39
Superiority of, 54
superior to common people, 38
The, 54
Children, Hawaiian, 32, 45
Chile, 360
Chilian strawberry, 255
China, 210, 222, 236, 260, 266, 269, 276, 281, 285, 291, 304, 305, 307, 320, 376, 377, 399
fish, 377
goldfish, 376
Chinch bugs, 425
Chinese banana [Maia], 258, 259
catfish, 377
ginger, 215
harrow, 282
horned nut, 285
lotus, 285
mantis, 429

orange, 266
palm, 237
pheasant, 307
reed-warbler, 308
snail, **436**, 438
sparrow, 304
thrush, 308
turtle-dove, 305, 430
violet, 248
Chitons, 467
Chocolate, or cacao (*Theobroma Cacao*). Is a small evergreen tree from 16—40 feet high in its native wild state in tropical America. Its fruit is a somewhat pear-shaped pointed pod, 10 furrowed, from 5—10 inches long and contains numerous large irregular seeds embedded in a sweet pulp. These seeds are very nutritive and agreeable in flavor and are used both fresh and dried as articles of food. They are roasted, ground into a paste, mixed with sugar and flavoring matter to make the chocolate of commerce. A few experimental trees are growing in Hawaii. They may be recognized by their large pointed leaves, the wine-colored new growth and the small flowers with inflexed petals hanging from the trunk and branches, and by the pods.
Chocolate-lined cone, **460**
Choice Hawaiian market fish, **362**
Chordate, 484
Christmas berry, 225
flower, 249
island shearwater, **310**, 312
Chrysanthemum aphis, 389
Chrysolite or olivine occurs commonly in Hawaiian lavas as green or olive-green, sometimes yellowish, orthorhombic crystals. They are essentially a magnesium-iron silicate; with vitrious luster and a hardness between 6 and 7. The name olivine is more commonly used by geologists.
Chrysophyllum (*see* Star apple)
Cigarette beetle, 395, 405, 418
Cinder cone, **160**
Cinnamon, 262
"Circassian seed," 203, 204
Circumcision (*see* Omaka)
Cirrhitidæ, 354
Cirrhitoid fish [Pilikoa], **374**
Cistelid, beetles, 418
City of refuge, **48**, 51
at Honaunau, 182
Cities on Oahu, 110
Cities, Towns, Villages, Places, etc., on OAHU—Honolulu, Aiea, Pearl City, Waipahu, Ewa Mill, Waianae, Waialua, Wahiawa, Kahuku, Laie, Hauula, Heeia, Kaneohe, Kailua, Waimanalo; on HAWAII—(In Kohala) Puako, Kawaihae, Mahukona, Hawi, Kapaau, Makapala, Waimea: (In Hamakua) Waipio, Kukuihaele, Honokaa, Paauhau, Paauilo, Kukaiau: (In Hilo) Ookala, Laupahoehoe, Papaaloa, Hakalau, Honomu, Onomea, Papaikou, Hilo Town; (In Puna) Keaau, Nine Miles, Mountain View, Pahoa, Kapoho, Kalapana: (In Kau) Pahala, Hilea, Honuapo, Naalehu, Waiohinu; (In Kona) Papa, Hookena, Honaunau, Napoopoo, Kainaliu, Keauhou, Holualoa, Kailua; on MAUI—Lahaina, Olowalu, Waikapu, Wailuku, Waihee, Kahului, Puunene, Spreckelsville, Paia, Haiku, Hamakuapoko, Makawao, Pauwela, Huelo, Keanae, Hana, Kipahulu, Kaupo, Ulupalakua, Kihei: on KAUAI—Lihue, Kapaia, Hanamaulu, Kapaa, Kealia, Anahola, Kilauea, Kalihiwai, Hanalei, Waiuiha, Haena, Koloa, Lawai, Eleele, Hanapepe, Makaweli, Waimea, Kekaha; on MOLOKAI—Kaunakakai, Kawela, Kamalo, Kalaeloa, Pukoo, Honomuni, Pauwalu, Waialua, Halawa, Lepau, Wailau, Pelekuna, Kalawao, Kalaupapa: on LANAI—Maunalei, Manele.
Citron, 265
Citrus fruits, 248
fruits, Pests of, 265
leaves, Scale on, **384**
Clam(s), 443
Fresh-water, **436**, 440
Heart=Heart shell, **456**
Round, 445
Tent, 446
Venus, **456**
Clark, Dr. A. H. (Zoölogist), 497
Classes among the Hawaiians, 54
Classification (*see* Nomenclature)
of (*see* species in question), 415
Clavicorn beetles, 416
Clay not used in pottery, 59
Cleanliness of Hawaiians, 38
Cleghorn, Hon. A. S., 307
Chick beetles, 417
Cliff disintegration, Example of, **136**
Cliffs, Napali, 107
Sea, at Wailau valley, **136**
Sea-formed, on Hawaii, 150
Climate, 33
Climate. While the Hawaiian language does not have a word which is the equivalent of our word climate, the language is rich in weather words. The dictionary gives 86 words pertaining to clouds, 82 to precipitation, 139 to wind movements, 23 to temperature, 11 to optical meteorology, 18 to electric meteorology, and 12 general weather words.
Climate, changes in. Abundant evidence exists to prove that the climate of the islands has undergone changes in the past sufficient to seriously effect the plants and animals. (*See* Diamond Head, Geology of, Forests, Deforestation ,etc.)
Clinkstone. A name applied to phonolite because of its metalic, clinking sound when struck. It is a common product of Hawaiian volcanoes and was used by the natives in making stone adzes, etc.
Clinkstone, uses of, 74
Cloak [ahuula] of feathers, **44**, 75, 333
Clothes-moth, 405, 423
Clothing (*see* Tapa)
of Hawaiians, 38
Cloud belt on Haleakala, 143
cap over Kamalo, Molokai, **142**
effects, Hilo Bay, **352**
in Haleakala, **145**
Clover, 286
Club-Mosses (*Lycopodiaceæ*). Perhaps one hundred or more species occur in the group. They grow in crevaces of rocks, forks of trees and among other plants usually occurring in the higher forested regions.
Club rush, **198**
-spined urchins, 487
Clubs, War, 79
Coan, Dr. Titus Munson, 45
Coan, Rev. Titus (Early Missionary), 157, 172, 173
Coan's account of 1852 eruption, 157, 158

Coast line of Oahu, 129
of Molokai, Northwest, **142**
scenery on Hawaii, **344**
scenery (Oahu), **130**
Coastal (208). Pertaining to the coast or shore.
Coastal plain of Maui, 138
Coccids, 427
Cock-fighting. At Pau o Keokeo, on Hawaii, immense crowds of Hawaiians gathered to witness the cock-fights in former times. The pens still stand as they were in the time of Umi—three and a half centuries ago.
Cock fighting, 86
Cocklebur, **196**, 287
Cockroaches, 402, 428
Number of species of, 428
Coco grass, 287
Cocoanut cups, 62
cord, Uses of, 75, 81
fiber, Use of, 73
hula drum [pahu hula], **64**
Island (Volcanic), **150**, 175, 176
Island, Palm trees on, **150**
leaf-rib broom, **76**
leaf-roller, 395
leaf, Use of, 65
milk (juice), 235, 236
oil, Uses of, 222, 236
palm as a symbol of hospitality, 233
palm (*see also* Palm), 233
Habitat of the, 233
History of the, 235
leaf-roller, 422
shell drums, 82
spoon, 62
tree, **28**, **234**
trees (Laysan Island), **92**
trees protected from rats, 235
Tree rats in the, 235, 292
uses of the, 236
Varieties of the, 236
wood hula drums, **70**
Yield of a, 235
Cocoanuts, 67
Falling, danger from, 235
how distributed, 236
Cocoon, Silkworm, 399
Cocoon (309). The silky envelope which the larvæ of many insects spin as a covering for themselves in the resting (chrysalis) stage.
Codiæums, 249
Varieties of, 251
Cœlenterata, 480
Coffee, **190**, 279
aphis, 391
-bean shells, 459
-bean weevil, 395
berries, Size of, **270**
Harvesting of, 280
How gathered, **270**
Kona, 219
native of, 279
Picking, **270**
Types of Hawaiian, 280
when introduced, 279
Coffer-fish, 375
Coiled snail shell, 439
Colburn, J. F., 445
Coleus, 251, 386
Collumella defined, 450
Collecting ground at Waikiki, **116**
on the reef, **478**
outfit, **478**
Water glass for, **478**
Collection of taxes (*see* **Taxes**)
Colonial habit, Example of, **402**, **404**
hydroids, 481
Colony of Hawaiian tern, **316**
Color of Hawaiians, 38
variation in land shells, **432**, **433**
Colors, Tabu, 73
Columnar basalt, 109
Commelina (*see* Honohonowai)
Comments, notes, observations, **where found**, 10
Commercial Pacific Cable Company, **93**
Common amaranth, **196**
beetles, wasps, bees, flies, etc., **406**
brake, 223
corals, **486**, 475
crabs, **482**
crabs from the coral reef, **474**
dolphin [Mahimahi], **362**
ferns on Oahu, **228**
Hawaiian birds, **337**
Hawaiian fish, **366**
Hawaiian sponges, **494**
insects, **392**
littoral species, 195
marine bivalves, **456**
marine plants at Waikiki, **492**
mealy-bug, 391
people, Houses of the, 58
people, How ruled, 55
people, Marriage among the, 45
people, The, 54
plants of the lower forest (Oahu), **202**
roadside plants, **198**
sea shells, **460**
side, **196**
tunicates, **490**
weeds, **196**
Compass, Variation of, **88**
Complete domestic arrangement, 58
Composite, **214**
High mountain, 227
Compounded fish bait, 242
Compressed (364). Flattened from side to side; narrower than high.
Concealment of bones (*see* plate 8)
Conch shells, 457
Spotted, **470**
Concrete, 129
Condensed history of Kilauea, 183, 188
Cone, Cinder, **160**
building in Halemauman, **174**
Chocolate-lined, **460**
Hebrew, **460**
Lettered, **460**
shells, 453
Conqueror, Spoils of war belong to, **53**

Conger-eel, 355
Conglomerate. A rock composed of cemented gravel.
Connecting bars [iako] of hau, **80**
Conoid harp shell, **460**, 452
Conservation, Kamehameha I on, 221
of fish supply, 359
Consonants, Hawaiian, 39
Conspicuous insects, **392**
Contents, 15-22
Convergence, Examples of, 481
Convict fish [Manini], 372
Convolvulus, 197
Cultivated, 248
Cook, Capt. James (Navigator), 153, 168, 182, 209, 287, 291, 295
Cook killed at, 182
Cook's monument, Inscription on, **84**
Cooke, Dr. C. Montague (Conchologist), 435
Cooking (*see* imu, *also* plate 4)
bananas, 259, 260
birds, Hawaiian method of, 324
shellfish, Native method, 443
Coot, Hawaiian, **323**, 326
Coral(s), 475
and coral rock, **488**
Branching, **486**, **488**
Collecting, **142**
Common, **486**
Common genera of, **477**
Dead, **488**
Eight-rayed, 479
growth prevented by, 211
How to clean, 479
lime, 129
Mushroom, **488**
Organ pipe, 479
polyp, Work of, 93
Reef-building, **486**, **488**
rock, **486**
rock, Worms from, **490**
"tree," 203
Worms in, 497
Corallines, **498**
Coral reef(s) at high tide, **478**
at Molokai, 135
at Waikiki, 131
Early formation of, 220
Elevated, 115
Elevated (Ford Is., Pearl Harbor), **130**
Elevated (Pearl Harbor), **130**
Geologic significance of, 477
Miscellaneous animals from, **490**
on Oahu, **110**
Plants and animals from (part one), 468
Plants and animals from (part two), 485
The growing, 476
Cord (*see* aha)
Cordage from morning-glory vines, 197
Corduroy road (fern stems), **200**
Cordyline, 251
Corolla (195). The leaves of the flower within the calyx; usually bright colored.
Corn aphis, 389
cutworm, 396
leaf-hopper, 389
moth, 423
Coronation celebration, Hula dancers at, **78**
Corpulency among the Hawaiians, 38
Coronet barnacles, 475
Cosmetics, Hawaiian, 215, 222
Cotton, 203
aphis, 391
boll-worm, 281, 399, 423
Early export of, 281
Native, 199
peculiarities of the fiber, 281
Pests of, 399
Sea Island, 281
tree, 281
Upland, 281
Varieties of, 281
Cottony cushion scale, 391
guava scale, 391
Council of chiefs, 55
Cowboys, **282**
Cowries as food, 458
Cowry, 447
Ancient pule to the, 459
Hump-backed, **460**
Isabella, **470**
Madagascar, **470**
Money, **470**
Snake-head, **470**
used as medicine, 459
shells, 457
shells as bait, 458
shells as leis, 458
Crabs, 468, 469, 491
Brackish water, **436**
common, How to identify, 471
Hermit, **474**, 471
Sand, **496**
Small, **482**
Crab-like animals, **482**
louse, 400
Crack in the the floor of Kilauea, **184**
Crater formation shown by Dewey crater, **160**
Hotel, 177
Koko (Oahu), from Haunama Pay, **128**
"lake" on Hawaii, **160**
of Mokuaweoweo, **186**, 155
on Haleakala, 143, 152
Crawfish, 468
Creeper, Mexican, 248
Mountain, **250**
Creeping fig, 245
grass, 208, 286
Crenulated auger shell, 455
Crickets, 428, 429
Common, chirp of, 430
Crime, 55
Crinoids, 495
Cross, Dr. Whitman (Geologist), 153
"Cross bill" finch, 333
Crotons, **234**, 249
Croton scale, 391
Crow-foot, **196**

Crow, Hawaiian, 327, 335
Crowns, Pineapple, 261
Crystal cave, 146
Crystallizers, Sugar, 275
Cryptogams (191). Plants of low order; flowerless plants having no stamens or pistils, but reproducing by spores (as ferns, fungi, etc.).
Cub-shark, Hawaiian, 340
Cucumber fly (melon fly), 387
Cultivated fruits, 258
plants (*see* Garden plants)
plants, 246
Cultivation, Effect of, on native flora, 201
Curculios (*see also* weevils), 418
"Curiosities," Shells as, 469
Curlew, Bristle-thighed, 310, 316, 324
Curious fishes, 374
forms of lava, 186
Hawaiian fish, 366
insects, 392
native plants, 206
plants and plant-like animals, 498
Custard apple, 266
Cuscuta (*see* Popolo)
Custom the basis of law, 5
Cup and saucer limpets, 462
Cutter's cavey, 293
Cutting and stripping sugar-cane, 278
Cuttlefish, 302
Cutworms, 396
Black, 422
Cuvierian organs, 495
Cycads, 237
Cycas, 240
Cyclones are unknown in Hawaii
Cymes (219). Flower cluster in which the central flowers are first to open.
Cypræa, 447
Cyperus (*see* Ehuawa)
Cypress roach, 388
Monterey, 237
Cytandra (*see* Mapele)
Cytheria, Hawaiian, 456

D

"Daddy long-legs," 409
Daggers, 79
Dall, Dr. W. H. (Conchologist), 117
Damage by wild goats, 221
Damsel-bugs, 426
flies, 424
Dana, James D. (Geologist), 94, 113, 477
'Dance,' Albatross, 314
Dancing (*see* Hula)
Darkling beetles, 418
Dark-rumped petrel [Uau], 310
Darwin, Charles (Evolutionist), 94, 435
Date, Indian, 245
palm, 238, 246, 236
palm, Fruit of, 236
Dates, 264, 236
of eruptions of Halemaumau, 183-188
of eruption of Mauna Loa, 183-188
Day mosquito, 387
Dead coral, Worms from, 490
Death caused by gods, 49
in the royal family, presaged by, 354
Decay, (Geologic) Period of (Oahu), 121
Deciduous tree, Poinciana, 244
Examples of, 194, 203
Deer axis, 296
introduced, 296
Molokai, 296
Spotted, 296
Defense, Method of, 51
Deforestation. Less than a century ago the trees on the mountains of east and west Maui met on the low plain connecting them; Lanai and Molokai were well covered. The plain at Wahiawa, on Oahu, was well covered with large trees, while the native forest extended well down to Honolulu. Kauai was also well covered well down toward the sea-shore. The changed condition now existing is generally ascribed to over-stocking the forest with cattle.
Deformed inflorescence, 220
Degration through quiescence Example of, 473
Deification of nature (*see* Religion)
Demerara almond, 245
Dentate (217). Toothed.
Depth of Kilauea, 170
Depths of harbors (*see* Harbor anchorages)
Depths of Inter-Island channels (greatest depths obtained in fathoms): Niihau—Kauai channel, 550; Kauai-Oahu, 1872; Oahu-Molokai, 374; Molokai-Lanai, 73; Molokai-Maui, 135; Lanai-Maui, 42; Maui-Kahoolawe, 100; Maui-Hawaii, 1032. Depth five miles south of Keauhou (Hawaii), 1285 f.; five miles south of Diamond Head, 337; five miles south of Waimea (Kauai), 1019. Granting a uniform elevation of the group sufficient to connect the islands from Niihau and Kauai to Kohala, on Hawaii, with dry land as suggested by Dr. H. A. Pilsbry and others, the *old mountains* on the various islands in their youth doubtless stood much higher than at present, but in no case would their youthful altitude, of necessity, be greater than that shown by Haleakala, Mauna Kea and Mauna Loa as they now stand. Assuming the existance in remote time of a large pan-Hawaiian island there is much reason to suppose that the old mountain cones were slowly built up by additions of new lava as their bases sank beneath sea level, so that elevation of the cones and general submergence of the great island might proceed at the same time. Should submergence take place as postulated Kauai would first be detached: Kohala (and Hawaii) next; Oahu third, Niihau fourth, and Molokai, Maui, Lanai, Kahoolawe last and at about the same time. There is much biological evidence to substantiate this view of the order of separation of the high islands of the group.
Dermestes, 417
Descent into the crater of Kilauea, 178
of rank, 46
Description of (*see* order, family or species in question)
Destructive insects, 380
Development of a fern frond, 228
"Devil's picture frame," The (lava forms), 186, 180
Devil, Sea, 347
Dewey crater (Mauna Loa) in eruption, 160, 161
Diagram of sugar mill, 274

Diamond Head, **80, 115, 121**
Age of, 124
Breccia, at, 219
Concretions at, 131
Fossils from, **118**
Fossils at, 219
from Waikiki, **116**
Height of, 115
History of, 219
Map of, **118**
Plan map of, **118**
Pot-holes at, 131
Root casts at, 131
Sea slope of, 131
Speculations based on, 115
Tufa cone of, **80**
Vertical section through, **118**

Diatomes. Both marine and fresh water species abound in the group. Recent study of material collected by the Albatross, and by the writer, has added many species to the list of this group of single-celled plants from this region.

Dibble, Rev. Sheldon (Historian), 68, 221
"Die-back," 265
Digger, The [oo], 75
wasps, 413
Dikes, 121
Examples of, on Punchbowl, 121
Diœcious plant, Papaya, examples of, 263
Dip nets, 341
Large, **344**
Dipthongs, Hawaiian, 39
Dipthongs. A dipthong is a union of two vowels pronounced as one syllable. In uttering a dipthong both vowels are sounded but are so blended as to be considered as forming one syllable. In scientific nomenclature proper diphthongs occur frequently and are usually indicated by the union of the letters involved. In the present volume the italic æ and œ used in the Latin names occuring in the foot-notes and the explanation of plates are so similar in appearance that as a convenience, in the varification of spelling, those words formed with an œ have been here collected. Those occurring in the description of the plates are: Bœrhaavia diffusa, Clermontia cœrulea, Cœlastrea tenuis, Cœlenterata, Crangon = (Alpheus) lœvis, Ipomœa spp., Œchalia grisea, Parexocœtus brachypterus, Phiœma sp., Phœnix dactylifera, Scævola Kœnigi. Those occurring in the foot-notes for the text are: Bœhmeria nivea, Cœlenterata, Cœlophora spp., Exocœtidæ, Exocœtus volitaus, Ipomœa spp., Œdemeridæ, Œstridæ, Œstrus, Parexocœtus brachypterus, Phiœma, Phœnix dactylifera, Pœcilliidæ.

Disease, caused by gods, 49
Diseased inflorescence, 202
Diseases of the banana, 260
Pineapple, 261
Disemboweling weapon, 81
Dishes, 59
Disk-head fish, 367

Distances by sea from Honolulu to Kalaupapa, 52 miles; Lahaina, 72 m.; Kahului, 90 m.; Hana, 128 m.; Maaleae, 86 m.; Makena, 96 m.; Mahukona, 134 m.; Kawaihae, 144 m.; Kailua (on Hawaii), 157 m.; South Point (Ka Lae), 233 m.; Honuapo, 244 m.; Hilo (direct), 192 m.; Hilo (via Kawaihae), 230 m.; Nawiliwili, 98 m.; Koloa, 102 m.; Waimea, 120 m.; Hanalei, 125 m.

Distances on Hawaii, **148**
on Kauai, **104**
on Maui, **134**
on Oahu, **110**
(*see* Overland Distances)
Distilling (*see* Okolehao)
Distribution of fauna and flora explained, **290**

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Districts: On OAHU—Honolulu, Ewa, Waianae, Waialua, Koolauloa, Koolaupoko. Honolulu, with about one-fourth the population of the whole group, is the capital city. On KAUAI—Waimea, Koloa, Lihue, Kawaihau, Hanalei (including Napali); on MAUI—Lahaina, Wailuku, Makawao, Hana; on HAWAII—Kohala (divided into North and South Kohala), Hamakua, Hilo (divided into North and South Hilo), Puna, Kau, Kona (divided into North and South Kona); on MOLOKAI—Undivided.

Divergence (433). Differentiation in action or character.

Diviners (*see* Nana uli)
Diving beetles, Predaceous, 416
boys in Honolulu harbor, **60**
from high places, 86
Division of lands (*see* King and the lands)
Dixon, Capt. George (Navigator), 431
Doctor-fish, 372
Dodder, 199, 204
Dodonæa (*see* Alii)
Dog-flea, 401
Dog whelks, 451
-fish, Hawaiian, 346
Food for, 67
fish, Hawaiian, 346
-shark, **340**
teeth, use of, 82
-tick, 401
trays, 61
Wild, 295
Dogs' teeth, use of, 77

Dolium, **460**, 461
Dolphin, 300, 354
Common, **362**, 301
Whale, 355
Domestic animals, 287
animals, Hawaiian, 295
arts of women, 46
Dorsal fin (353). The fin on the back of a fish.
Dosalane (*see* Hawaiian igneous rocks)
Double canoes, 29
gang plow, **278**
pronged fish spear, **344**
war canoe, **48**
Dove, Chinese turtle, 305
Eggs of, 305
shells, 453
shell, **470**
shooting, 305
Dowsett, Capt., 97
Reef, **88**, 97
Dracæna, 251
[ki], **190**, 251
Dragon fly [Pinau], **392**, 423
larvæ, 440
nymah, **436**
tree, 211
Dredger dump, Shells collected on the, 447
Drepanididæ, Genera of, **332**
Various genera of, **330**
Dress of Hawaiian women, 38
Dried fish, 364
Drill, Rotary, 35
Drive, Date palm, **234**
Drowned valley (Hanalei), Example of, **106**
Kahana a, 131
Kahana, Oahu, an example of, **128**
on Kauai, Example of, **106**
Waipio a, **154**
Drum fish (Puffer), 367
heads, Hula, 346
Drums, Cocoanut shell, 82
Gourd, 82
Hula, 82
Drupe [Bot.]. A stone-fruit.
Dryland taro, 225
taro culture, 65
Duck, Foreign, 328
Hawaiian, **323**, 328, 335
Laysan, 318
Pintail, 328
Shoveler, 328
Dunes, Erosion of, **142**
Root-casts in, **140**
(*see* Sand dunes), 131
Dung beetle, 417
Dutch East Indies, 279
Duties of Hawaiian women, 46
Dwarfs, Work of, 359
Dyes for tapa, 69
Dye stuff. The Hawaiians had an extended list of materials which served as dye stuff for ornamenting their tapas. Among the plants so used were akoa, awapuhi, haa, niu, holei, mao, na'u, noni, ohia, olema, koa, pili (charcoal of), walahee ,etc. Other dyes were made from earth, charcoal, ashes, red ocher, etc.
Dye stuff, Source of, 205

E

Eagle fern, 223
rays, 347
Early voyages, 26
Difficulties encountered in, **29**
Ears slit as a mark of humiliation, **51**
Earth oven [imu], **36**, **66**
Earthquake of 1868, 159
Earthenware not made by Hawaiians, **59**
Earthworms, 440, 497
Earwigs, 415, 428
E-a (Sea turtle), 299
Eastern oysters, 445
East Indies, 235, 346, 497
Eating bananas, 259
poi, **76**
Echinoidea, 487
Echo trail, 178
Economic entomology, Study of, **380**
insects (part one), 380
insects (part two), 391
insects, Some, **384**
study of native plants, 283
Edible algæ, 502
mussel, Hawaiian, **456**
ohia, 216
snail, 438
Eel(s), **355**
-conger, 355
fishing, 242, 355
-like fish, 361
spear, 341
Species of, 355
and other curiously shaped fishes, **350**
Egg fruit (*Lucuma Rivicoa* Gætn.). A native of Brazil and of rare occurrence in Hawaii. The fruit is described as being "about the size and shape of an egg and tastes like the yolk sweetened."
Egg parasites, 382
of (*see* Species in question)
shells, 459
Eggs, Albatross, **316**
Fossil, 315
Eight-marked ladybird, 394
-rayed corals, 479
-rayed starfish, 489
Ehrhorn, E. M. (Economic Entomologist), 12, 410
Ehuawa. A species of sedge (*Cyperus laevigatus* Linn.) from which a strong cord was made; but its chief use was in the manufacture of of the fine Niihau mats. It is common in shallow sweet and brackish water.
Ekaha (Birds-nest fern), **190**, **240**, 223, 253
Ekaha, **228**
Ekaha-ula=Ekaha
Elæocarpus (*see* Kalia)
Elepaio, 329
Hawaii, **337**
Kauai, **334**
Oahu, **337**

Elevated coral reefs, evidence from, 127
coral reef (Pearl Harbor), **130**
reef at Kahuku, 132
Elevation and submergence (*see* Depths of Inter-island channels)
of Hawaiian Islands (*see* Depths of Inter-island channels)
Elevations on Maui indicated, **134**
on Molokai, indicated, **134**
(*see* Mountains)
Elliptical (216). Oblong or oval with the ends similarly rounded.
Ellis, Rev. William (Early Missionary), 42, 154, 169, 171, 172, 182, 221
Embalming, Hawaiian method of, **52**, 223
Embalming. Sometimes the human body was partially embalmed by being salted and dried. *See* plate 8.
Embayed shore-line, **270**
Emerald shell, **470**
Emerge (382). To come out of the covering: to come forth, as a butterfly from a cocoon.
Emergency diet, 69
Emerson, Jos. S., 342
Emerson, Dr. N. B. (Ethnologist, Hawaiian scholar), 459
Emoloa, **224**
Encampment shell, 446
Endemic (193). A species peculiar to the islands: 'autochthonous' is often used in the same sense. Peculiar to and hence characteristic of a given locality.
Endemic fauna. Dr. Perkins estimates that nineteen-twentieths of the endemic species now existing in Hawaii have their home in the true forest belt on the islands.
Endemic plants, 191
Endogenous plant, Palm example of, 233
End of new flow (1907), **162**
of book one, 288
of book two, 504
Enemies, bones, use of, 63
of lantana, The natural, **384**
Engines, Traction, on a plantation, 274
used in plowing, **278**
England, 291, 307, 401
English names. The approved as well as current English names are given in the text, and are referred to proper scientific names. (*See also* Nomenclature.)
English, 304
skylark, 307
sparrow, 277, 304
sparrow, Eggs of, 304
Engraver beetle, 418
Entire [Bot] (252). The edge of the leaf is perfectly smooth, not being notched, toothed or otherwise modified.
Entomological collection, Portion of, **380**
Entomological Society, Hawaiian, 411
Entomologists (383). One versed in or engaged in the study of insects.
Entomology, Economic, The study of, **380**
Entrance to Pele's Reception room, **184**
Environment effect of, 441
effect on habits, 39
its effect on the people, 31
Natural, its effect, 31
Eocene, 117, 127, 220
Epidermis [Mollusca] (450). The outermost covering of the body of an animal.
Erect [Bot.]. Said of plants when they grow upright from the root.
Erosion by the sea, Example of, **142**
Examples of, Molokai, **136**
Example of in sandstone, **140**
in the Waianae range, **122**
Koko Head example of, **472**
of the Koolau range shown, **112, 130**
of Waipio valley ,**154**
on Kauai, Example of, **106**
on Molokai, Example of (Halawa), **140**
Sea, on Hawaii, **150**
Eruption and flow of 1840, 172
General view of (1905), **162**
on Mauna Loa (Dewey crater), **160**
1905, Party visiting, **162**
Eruptions of Kilaueu, **174**
Escaped (205). Introduced as a domesticated plant or animal but now run wild.
Escaped introduced plants, **200**
Establishment of the Hawaiian race, 30
Ethnographic collection, Hawaiian, **57**
groups in the Bishop Museum, **64**
Eugenia, 267, 268
Eulima shell, **470**, 462
Euphorbias, 249
Rubber producing, 283
Wild, **196**
Europe, 208, 249, 269, 286, 292, 377, 428, 451
Europeans, 191, 205, 215, 259, 284, 297, 316
Evaporating pans, Sugar mill, **274**
Evaporators, Sugar, 275
Evergreen-like trees, 237
Evidence from artesian wells, 220
of elevation at Pearl Harbor, **130**
Evolution, Material for study of (shells), 435
of the Hawaiian birds, 338
Example of color variation, **432**
of fore-plain (Kamalo), **142**
of Pahoehoe in Kilauea, **184**
of promontory [Kohala], **148**
of rain forest, **190**
of sheet lava flows, **122**
of sub-aërial erosion, **136**
of Talus debris, **136**
Exchange of wares among Hawaiians, 74
Exchanges, Shell, 441
Executive, judicial and legislative functions, 54
Executions were anciently in the form of assassinations, without any trial or any public sentence, and were performed in the most rude and barbarous manner by assault usually at night. Often the victim was attacked from the rear and done to death by strangulation or by breaking the back.
Exile-oil, 252
Exotic (381). Not native; introduced from a foreign country.
Exotic flora, 231
plants, **246**
plants (Government Nursery), **238**
Exposed fossil root-casts, **140**

Extinct birds, Explanation for, 335
Hawaiian birds, 333
oyster, 444
Eyes of Hawaiians (characteristic), 38

F

Fairy tales. The stories of the achievements of the menehune people correspond with the fairy tales of other races. The menehunes are sometimes represented in Hawaiian legends as a race of industrious dwarfs that employed themselves in many ways, as building heiaus, fish ponds, etc.

Falling (palm) leaf, 232
Falls in Halawa valley, **142**
of Moaula, Middle, **136**
Wailua, **102**

False [Mynah] (306). Having some superficial resemblance to a given species or thing.

False geranium, "Cheeses," **196**
koa, **198**
mallow, **196**
operculum, 439
scorpions, 408
Familiar Hawaiian birds, **337**
insects, **392**
Family, 42, 43
discipline among Hawaiians, 45
(*see* Nomenclature)
Fan palm, **240**, 236
Fans, **57**, 62
Hawaiian, **70**
Fan-tailed fly catcher, Hawaiian, 329
Farmer, Chinese, **282**
Farming, Small, industries, **270**
Father of race, Home of, 50

Fauna (328). The animals living in a given area.

Fauna and flora, Distribution of, explained, **290**
Hawaiiensis, 407, 414
Isolation of explained, **290**
Native insect, 411
Fearless birds on Laysan, 314
Feather cape [ahuula], **70**
cloak [ahuula], **48**, 75
leis, **57**, 77
ornaments, 75
robes, how made, 75
robe of Kamehameha I, 75
-stars, 497
Feathers, Use of, 75, 77
Use of (*see* species in question)
Features of Hawaiians, 38
Federal Experiment Station, U. S. (*see* Hawaii Agri. Exp. Sta.)
Feeding habits of (*see* species in question)
Female children, how regarded, 46
line, Rank descended through, 46
Females, Special tabus for, 46
Fern or ferns
aphis, 389
Bird's nest, 223, 253
Birds nests (Cultivated), 240
Boston, 253
Eagle, 223
Fish-tail, 253
frond, Development **of a, 228**
Giant [Heii], **190**, 223
Maiden hair, 223, 419
roots, uses of, 223
stem road, **200**
Tree, 222, 253
Uses of, 221, 223
Ferns, 253
along Olympus trail, **206**
in the moist woods (Hawaii), **190**
in upper forest, 227
Number of species and **genera of, 223**
Pulu, 222
Staghorn, **228**
Festooning vines, 234
Feudal organization of Hawaiians, **47**
Feudalism, 55, 56
Fiber, Cotton, 281
plant, Banana as, 280
plant, Sisal as, 280
plants, 69, 280
plants, Native, 217
Sisal, First step in making, **270**
Field and roadside plants, Common, **198**
boulders (Oahu), **130**
boulders (Waianae range), **122**
Introduced plants and animals **of the,** 231
laborers, **278**
mice, 293
of cane in blossom, **278**
and lower forest, Plants of, **212**
stone as building material, **129**
Fig, Banian, 283
Common, 245
Creeping, 245
native of, 267
Smyrna, 267
Figs, 266
Fiji, 397
Files, Stone, 75
Finch, California house, 304
-like birds, Hawaiian, 331
Finches, "Cross bill," Hawaiian, **333**
Finger bowls, **70**, 61
Fire, 62
Fire, How carried, 62
Hawaiian method of lighting, 62
lake in Kilauea, **174**
Legend of origin of, 326
Method of making, 40
how made, 328
Fire-cracker vine, 250, 248
Fireplace, 59
in the Volcano house, **184**

Fires, Forest. Forest fires of a more or less destructive nature occasionally occur. They were also known in ancient Hawaii. Fire was used to some extent by the natives to clear land in the forest for native crops.

Fires, trash, 275

First fruits. When the first fruits of any crop were ripe they were offered to the family gods on the proper day of the moon.

First impressions of Honolulu, 231
land shell described by, 431
slain in battle ,a sacrifice, 53
Fish, Amber, **362**
bait 242
bait, Method of securing, 343
Baking, 349
-baskets, Hawaiian, **70**
-baskets, Native, 341
-baskets shell, **470**, 451
Blue parrot, **370**
for boiling, 349
Butterfly, **370**, 353
Cirrhitoid, **374**
Common, **362, 366**
Conservation of, 359
Dried, 364
eaten raw, 355, 365
fauna, Character of the, 351
Floating, 355
Flying, **366**
Flying gurnard, **374**
Fresh water, 376
Frying, 349
Goat, **362, 366**
Gobies, **374**
Lizard, **350**
market, Fish at the, 348
Moorish Idol, **370**
-moth, 403, 430
Needle, **350**
nets, 73
Pan, 349
Parrot, **370**
pens, 341
photographers (How made indicated), 356
Pilot, **366**
pond, **270**
ponds, The first, when built, 27
poison, 341
use of, 358
Poisonous, a, 367
Porcupine, **370**
Protection of, 359
Scorpion, **374**
snare, 242
-spear, Double-pronged, **344**
Spearing, **344**, 341
Species of, 348
Squirrel, **362, 366**
Sucking fish attached to, 368
Surgeon, **370**
Surgeon, striped, **362**
Sword, **366**
-tail fern, 253
Thread, **366**
traps, 341
traps, Hawaiian, 70
Trigger, **370**
Trumpet, **350**
Trunk, **374**
Wrasse, **366, 370**
Fisherman with a throw net, **344**
Hawaiian, **472**
Fisher, Dr. Walter K. (Zoölogist), 12, 489, 493, 314
Photogarphs by, 14
Fishes at the Aquarium, **356**
Curious, **366, 370, 374**
Curiously shaped, **350**
Deep sea, 354
Hawaiian (Part one), 338
Hawaiian (Part one), 348
Hawaiian (Part two), **374**
Fish gods. Several species of fish arrive in large numbers on the coast every year in their respective seasons. The fish first secured was always carried to the fisherman's heiau and there offered to the fish god whose influence, it was thought, had driven the school of fish to the land. It is suggested that the natives, at some remote date, had seen the fish pursued through the islands by sharks and that the occurrence may have led them to respect the shark as a powerful god of the fishermen.
heiaus, 50, 73
Fish-hooks, Bone, ivory, tortoise shell, 242
Fish-hooks were made of shell, bone, tortoise-shell and ivory; iron was substituted in most cases at an early date. But few fish-hooks [he makau] are now made in the ancient style.
Fishing, 73
Ancient method of shark, 343
and idol worship, 73
apparatus, **64**
at night, 242
birds, 325
equipment, Ancient Hawaiian, 339
from sailing vessel, **344**
from the jibboom, **344**
Hand, 242
in former times, 339
in Hilo Bay, **352**
Reef, **344**
Religious ceremony observed, 339
Shark oil, 346
with a net, **344**
Fishing torch. Torches were made of kukui nuts strung on a rush, or on a cocoanut mid-rib and bound together with ki leaves. They would burn in almost any kind of weather. The natives believed that when the torch burned poorly, the fishing would be poor, but if it burned bright the fishing would be good. The light from the torch blinds or dazzles the fish. Sometimes a fire is made on the bow of the boat to aid in fishing. Often the blinded fish may be killed with a club.
Fish-lice, 468
Fish-line container, **57**
of olona, 217
Five-fingered morning-glory [Koali ai], **192**
Five-sided starfish, 489
Flamboyant tree, 244
Flame tree, 244
Flashlight view Pele's reception room, **170**
Flat black-scale, 391
Flatfish, 360, 371
Flat-worm, **490**, 477
Fleabane or Horse-weed [Iliohe], **262**, 287
Fleas, 401, 419
Flesh-colored cowry, 458
Flesh fly, 387, 419

Flies, 419
Common, 406
Flightless rail killed as sport, 293
rail, Laysan, 314
"Floating out" algæ, 501
Floor at Haleakala, 145
of Keanakakoi, 186
of main crater, Kilauea, 166
Flooring, Hard wood, 215
Flora (189). The plant life of a given region; in a similar way the 'fauna' includes the animal life.
Flora, Bog (Molokai), 218
Development of the, 189
Exotic, 231
Isolation of explained by subsidence, 290
Isolation of the, 189
Littoral, 195
Mountain bog, 229
Native, 192
of the group, 189
Relations of the, 189
Sources of the, 191
The island, 189
Variation in, from island to island,, 193
Floral zones, 195
zones, Lee and windward sides differ, 222
Florida, 364
red scale, 384, 391
Flounders, 371
Flow from Halemaumau, 174
of 1832, 170
of 1907, End of, 162
of ropy lava, 162
structure of lava, 186
Flower leis, 77
of the taro, 66
peddler, 246
"Flower pots," Lava (Puna), 156
Flowering plants (native). Except for the red flowers of the ohia tree there is very little in the way of conspicuous flowering plants in the native flora. Other species with interesting flowers and foliage occur such as *Gardenia*, *Hibiscus*, *Hillebrandia*, certain *Compositæ*, *Freycinetia*, *Sophora*, the *Lobeliaæ*, etc., but they seldom attract the attention of the casual observer by reason of their color alone.
Flowers as ornaments, 38
form for adornment, 38
Flume, Modern, 28
Flute, Nose, 82
Fluted scale, 391
Fly, Black, 265
Dragon, 392, 436
transmitting infant paralysis, 419
Fly-catcher [Elepiao], 337
catcher, Hawaiian, 329
Fly-flaps were small kahilis used as insigna of chieftainship and also as fly-flaps. (*See* plates 6 and 13.)
Fly-flaps, 60, 77
Flying fish [Malolo], 366, 355, 364
fish, Curious, 357
fish, Food for, 318
fish, shooting, 355
gunard [Lolo-oau], 374, 357
Folk songs, 41
Food fish, 348
fish, Abundance of, 351
fish, Chief, 359
of Hawaiian goose, 255
of (*see* species in question)
supply and population, 45
Two mollusks used as, 442
Foot racing, 83
Forage plants, 285, 286
Forbes, Charles N. (Botanist), 12, 226
Forbes, Rev. Mr. (Early Missionary), 139
Ford Island, Map of, 110
Foreign duck, 328
Forel, Prof. A. (Entomologist), 413
Foreplain at Kamalo, 142
Forest (*see* also Deforestation and Reforesting)
Birds of the, 328
Effect of animals in, 287
Introduced plants and animals of the, 231
jungle, View in a, 200
on Oahu, View in, 218
Plants from the lower, 201
Vegetation in the, 200
zone, Lower, 201, 210
zone, Middle, 228
zone, Upper, 227
Forms of lava, Curious, 186
Formation of sand hills, 90
Fortifications, Hawaiian, 51
Fossil (193). The petrified forms of plants or animals.
Fossils from Diamond Head, 118, 131, 219
eggs, 315
roots, 118
root-casts, Exposed 140
shells at Pearl Harbor, 130
tree moulds, 181
Fossores, 413
Foster, Mrs. Mary E., 300
Foundations of houses, 58
Four-banded fly, 388
Four-footed butterflies, 421
Four o'clock, 254
France, 205
Frear, Hon. W. F., Photographs by, 14
French cherry, 267
Frigates Shoal (volcanic), 88, 96, 97
Frigates Shoal, Discovery of, 97
Fresh water clam ,436, 440
fishes (Gobies), 357, 376
fauna of Oahu, 436
Hydra, 475
limu, 503
shells, 431, 438
shrimp, 436, 409, 469
Fresh water springs. Springs often occur in the ocean about the islands, as about Diamond Head, along the southern coast of Molokai, the east end of Maui, at Hana, at Kawaiahae, Keauhou and Punaluu. In some sections they determined the location of villages as they furnished a dependable supply of

fresh water. Springs are, of course, abundant in the mountainous districts on all the large islands.
springs in the sea, 127, 131
Frigate bird (*see* Man-o'-war bird), 312
mackerel, 361
Frog fish, **374**, 355, 449
Frogs, 297, 440
Species of, 297
Fronds (225). The leaf of a fern; that which corresponds with the leaf in higher plants.
Frontispiece (Portrait by Rochlitz, New York, 1909), **4**
Frost Shoal, 97
Fruit culture in Hawaii, 255
-fly, Mediterranean, 265, 386, 419, 421
-fly, not serious pest of Avocado, 262
Pineapple, 261
trees in the tropical setting, **36**
Introduced, 255
Island, 255
Native, 255
Native and introduced, **258, 264**
Tropical, in Hawaii, 255
Wild and cultivated, **258**
Fulgens group (Land shells), 433
Fulgur shells, 450
"Fulgurites" (Root casts which *see*),**118**
Fullaway, David T. (Entomologist), 12, 427
Fuller's rose-beetle, 394
Fumes, Sulphur, on vegetation, **170**
Fungi. Many species occur in the islands, usually in the native forests. An edible species occurs on decaying kukui wood. A number of species have been introduced since the islands were first discovered.
Fungi, Beetles in, 418
on Japanese beetles, 394
Fungus (242). Fungi consist of slender cells which form thread-like filaments. The group is a very diverse one including mushroom molds, etc., and forms one of the lowest orders of Cryptogams.
Fungus gnats, 419
Furnishings for a house, 59
Fusability of lava. The Hawaiian basalt is among the most readily fused of lavas. It melts at a temperature of about 2500° Fahr., depending somewhat upon its chemical composition.
Future state, The, 50

G

Galapagos, 300
land tortoise, 300
Galingale, **198**
Gallinule, Hawaiian, **323**, 326
Galls on Lantana, 385
Gambia, Whaleship, 303
Gambier Shoal, 94
Discovery of, 94, 95
Position of, 94
Gambling, 86
Gamboge tree, **246**
Games and amusements—
Bathing, 86
Boxing, 83
cats cradles, 86
cock fighting, 86
diving, 86
flying kites, 86
jumping the rope, 86
hiding the pebble, 86
foot racing, 83
mock fights, 83
noa, 86
of chance, 86
Pahee (*see* Pahee)
spear throwing, **84**, 83
"summer tobogganing," 86
Surf-riding, 86
top spinning (which *see*)
Maika (*see* Ulu)
Wrestling, 83
Gaps on Haleakala, Significance of, 144
Garcinia (*see* Mangosteen)
Garden grass, **196**
Introduced plants and animals of the 231
looper, 397
plants, **240**
Ramble in a Honolulu (part one), 231
Ramble in a Honolulu (part two), 243
spider, 409, 410
spurge, **196**
Gardenia, 386
Gardens, Submarine, 476
Ainahau, **234**
Tropical, **234**
Views in Honolulu, **246**
Gardner Island, **88**, 97, 103
Discovery of, 97
Gar-like fish, 364
Gartley, A., Photographs by, 14
Gasteropods, 441, 446
Gathering pipipi, **442**
sisal, **270**
sugar-cane, **274**
Gang plow, Double, **278**
Geckos, 296
Species of, 297
Geese, Foreign, 328
Genealogies and History, 26
Hawaiian, 26
Time measured by, 26
Genealogy. The genealogy of the more ancient Hawaiian chiefs are the same as those of the chiefs of the Society Islands; the names of the important idols in one group are the same as those in the other. The names of the principal gods were also much the same and all pointing to the common remote origin of the Polynesian race.
Genera (*see* Nomenclature)
of comomn corals, **486**
of common ferns, **228**
of plants, Number of, 191
General view 1905 eruption, **162**
Koko Head, **472**
summit of Mauna Kea, **154**
of Haleakala, **145**
of Kilauea, **186**
of a lava flow, **162**
of Moana valley, **270**

of mouth of Halawa valley, 140
of the Aquarium, **356**
of the Pali, **125**
of Waianae range, **122**
on Hawaii, **162**
on Hawaii, **154, 156, 160, 162**
on Oahu shore-line, **270**
Genesis of the Polynesian race, 25
Geologic development of Kauai, Stages in the, **290**
economic products (Oahu), 127
history of Oahu, 219, 220, 221
Geological survey, U. S., 153
Geographic position of the islands, 93
Geography of the Hawaiian Islands, 89-188
Geology of the Hawaiian Islands, 89-188
Geranium, 229
False, **196**
Wild, 287
Giant fern [Heii], **190**, 223
Giants among the Hawaiians, 37
Gill nets, 339
Ginger, 221, 257
Chinese, 215
Native, **202**, 213
Species of, 215
Glass-bottomed boat, Use of, on the reef, 131
Glenwood, 176
Gnats, Fungus, 419
Globe-fish, 365, 367
Globular mealy-bug, 391
snail, 438
Goat(s), introduced, 287, 295
-fishes, 372
-fish [Kumu], **362**
-fish [Mumu], **366**
Forest damaged by, 287
Wild, 295
Gobies, 355
Goby [Oopu], **374**
God of war [Kukailimoku], **52**, 77
Goddess of the hula, 82
Gods as spirits, 49
Fish, 73, 339
in human form, 49
Lesser, 49
of ancient Hawaii, 49
Plants and animals as, 49
Sacrifice to, in war, 53
Golden plover, 321
plover, Migrations of, 322
plover, Pacific, **310**
saddle oyster, 445
shower, 244
Goldfish, Varieties of, 376
Goober-nuts, 285
Goodrich, Rev. Joseph (Early Missionary), 155
Gooneys (Albatross), **316**, 312
Goose barnacles, 473
-berry, 257
Hawaiian, **310, 323**, 335, 336
mussels, 473
Gossamer-winged butterflies, 385, 421
Gould augur shell, 455
Gourd, Bottle, 209
Bottle, uses of, 61
calabash, **57**, 61, 209
containers, **68**
drums, 82
fish-line container [**poho aho**], **57**
hulu drum [**pahu hula**], **57, 70, 78**
masks worn, **48**, 79
water bottle [huewai], **57**
Gourds, how prepared for use, **61**
Ornamentation of, 209
uses of, 209
Government collection, Portion **of, 57**
Nursery, Old (King St.), **238**
Graft, A natural, **218**
Granadilla, 268
Grampus, 301
Grape, Isabella (*Vitis Labrusca*) **267**
Grape fruit, 265
Grapes, 266
Grass army-worm, 388, 396
Beach, **192**
Bermuda, 286
Coco, 287
Creeping, 208, 286
Garden, **196**
Guinea, 286
Hilo, 208, 286
Introduced species of, 286
Japanese, 287
Native, 286
Nut, **196**, 287
Pampus, **238**
Para, 286
Pepper, 287
Pili, 209
Stick-tight, **196**
Grasses, 208
Forage, 285, 286,
used for thatch, 286
Grasshoppers, 388, 428
Gray, Dr. Asa (Botanist), 283
"Great crack" in floor of Kilauea, **184**, 187
Greatest active volcano, 164
Green-breasted pheasant, 308
garden looper, 397
grasshopper, 429
islet (in distance) Midway, **90**
Lake in Puna, **160**, 176
pool, Puna, **160**
-scale, 391
silversword, 229
turtles [Honu], **294**, 300
Greenhouse pest, A, **384**
Grenadilla, **264**
"Grey backs" (Louse), 400
-backed tern, **310**, 318
-crowned tern, 311
rats, 291
shells, 453
sugar-cane mealy-bug, 389
Grimshaw, P. H. (Entomologist), **419** (Grimsham *error*)

Grindstone, or more properly whetstones (pohaku hookala) were made from hard, more or less gritty rock. They were used in ancient times for sharpening stone implements and in modern times may occasionally be seen in use for whetting knives, etc.
Grindstones, 75
Ground cockroach, 388
beetles, 416
cherry, 257
nesting birds, 311
-nuts, 285
pine [Wawae iole], **214**
Group, The flora of the, 189
in Bishop Museum, Bird, **310**
in the Bishop Museum, Ethnographic, **64**
Grouper [Hapuupuu], **362**, 369
Growing coral reef, 476
of taro, 63
Grubs, Beetle, defined, 416
Guano beds on Laysan, 315
Lighter load of, **92**
Loading, **92**
on Laysan, 95
rock, Pile of, **316**
Rate of deposition of, 97
Guava. The genus *Psidium* is represented in Hawaii by several species and varieties, all introduced from the West Indies, South America and China. The common guava (*P. Guajava* var. *pyriferum* Linn.) is the yellow fruited form common everywhere by the roadside. The sweet red species (*P. Guajava* Linn.) is also common and has a sweet, firm, red pulp. A white lemon-shaped form is also common in certain localities; it has a white, sweet pulp. Another variety of early introduction known as waiawi has small pear-shaped fruits with yellow flesh and numerous large seeds. The strawberry guava (*P. Cattleianum* Sabine) is a very different species with round red fruits. A variety (*P. C. lucidum* Hort.) with small, round, yellow fruit is also cultivated.
Guava, 263
Effect of on soil, 263
Lemon, **264**, 263
Species of, 263
Strawberry, 263
Uses of, 263
Guessing game [Puhenehene], Playing a, **76**
Guinea grass, 286
fowl, 308
pigs, 293
pigs, how used, 293
Gulch, A characteristic, on Hawaii, **150**
crossed by flume, **274**
Gulick, Dr. John T. (Evolutionist), 12, 119, 435, 437
Gum (*see* Varnishes)
Algaroba, 243
disease, 265
Kukui, 239
Gunard, Flying, **374**, 357
Gunnera, 225
Günther, Dr. A. (Ichthyologist), 377
Gunwale [moo] of ulu, **80**
Gurrey, A. R., Jr., Photographs by, 14
Gutter-tile shells, 451

H

Haae. The name applied to a beer made of sugar-cane after it is fermented and foaming.
Habitats, Bird, shown,**310**, **316**
Habitat of (*see* species in question)
Haena, Caves at, 108
Hair of Hawaiians, 38
how cut, 62
Hairy triton [Pupu ole], **460**, 450
Hala (*see* Lauhala), 204
leaves, Dried, **60**
Halapepe, **202**, 210
Uses of, 211
Halawa falls, **140**, **148**
valley, **140**, 133
valley, Falls in, **142**
valley, Hipuapua falls shown, **140**
valley, Moaula falls in, **136**
valley, Sacred grove in, **140**
valley, Sea beach of, **140**
Haleakala, 138
Ascent of, 143
Clouds in, **145**
Craters in, 143
described, 139
Floor of, 146
General view of, **145**
Hawaii peaks seen from, 144
Height of, 139
History of, 146
Inside of, **145**
Last eruption on, 147
Lateral craters in (indicated), **134**
Legend of, 139
Map of, **134**
Old mountain house on, **145**
Secondary craters in, **134**, **145**
Small craters on, 143
Silversword from, **206**
Sunrise on, described, 144
Sunset from, described, 143
Trail up, **134**
Halemaumau, after a breakdown, **166**
by day and night, 180
Condensed history of, 183-188
Cone building in, **174**
Flow from, **174**
from the Volcano House, **166**
in 1894, **174**
in 1909, **174**
Map showing, **148**
Near view of, **166**
overflowing, **174**
Rise and fall of lava in, 167
smoking, **166**
Spatter cone near, **184**
Steam cloud over, **166**
Vapors from, **166**
View looking down into, **174**
Halema'uma'u (*see* Ma'u)
Hauling sugar-cane, **274**
Half-beak [Iheihe], **350**
Half-bill, Hawaii, **332**
Maui, **334**

Half-bills (Fish), 358, 364
Haleone. A shelter built as a temporary residence (*see* plate 5, fig. 4.)
Ham maggots, 405
shell [Hihiwai], **456**
Hamakua coast, 151
Hawaii, **150**
Shore line of, **150**
spider, 410
Hammer-headed shark [Mano kihikihi], **340**, 346
Hana, 139
Hanai poepoe, **57**, **70**
Hanalei, Coast view at, **102**
river, **106**, 107
Hanamaulu, Kauai, **102**
Hanapepe valley, 107
Hanauma Bay (Oahu), **111**, **128**, 131
Hand fishing, 242
Handles, Kahili, 77
Hand-picking coffee, **270**
Hanging valleys on Hawaii, 151
Haniu. The thick, heavy end of a cocoanut leaf, used in beating the bottom and sides of a taro pond to render it water-tight.
Happiness, Abode of, 50
Hapu ili [Heii], 222
iii (*see* Hapu ili)
Hapu'u pu'u, 369
Hapuupuu (Grouper), **362**, 349
Harbor. Anchorage (Depths in fathoms). HAWAII—Hilo Bay, 2-7 (deeper at entrance); Kawaihae, 7; Kailua, 7; Keauhou, 2-8; Kealakekua, 8-20. MAUI — Kapuehokahi (Hana) Bay, 6-8; Kahului, 4-7; Napali, 3-5; Lahaina Road, 10-20; Maalaea Bay, 6-10; Makena, 8. MOLOKAI—Kaunakakai, 3-10. OAHU—Honolulu Harbor, 35 feet (33 feet at entrance), well dredged; Pearl Harbor dredged channel 31 feet (East Loch 3-6, Middle Loch 1-5, West Loch 1-9); Hanauma, 4-8; Kaneohe Bay, 4-10 (at entrance 15 feet); Laie Bay, 4-5; Waimea, 9; Waialua, 2-6; Port Waianae (open roadstead and steamer landing). KAUAI—Hanalei, 5-7; Waimea, 3-4; Hanapepe, 3-6; Nawiliwili Harbor, 3-5 (at entrance 22 feet); Hanamaulu Bay, 3-6. MIDWAY — Seaward Road 4½-7 (into Wells Harbor, 3½).
Harbor, Honolulu, 109
Pearl, 109, 211
Harbors (*see* Bays, etc.)
and landings on Hawaii, **148**
and landings on Kauai, **104**
and landings on Maui, **134**
on Oahu, **110**
Hardwood flooring, 215
Hare, Sea, 467
Harrow, Chinese, **282**
Harp-shell, Concoid, **460**, 252
Hau. Usually meaning the name of a tree the bark of which was made into tapa, ropes, etc., but the word also means snow, ice, frost, and is applied to a cool breeze.
Hau, **198**, 201
moth, 397
Native use of, **80**
Uses of, 201
tree bark, use of, 71
Hauhele, 202
Haukeuke, 487
Haupu, 105
Hawaii, A round-up on, **282**
Agricultural Experiment Station, 281, 283
Agriculture in, 269
Bays on, **148**
Capes on, **148**
Cattle raising in, **282**
Cave in lava flow (Rainbow falls), **160**
Characteristic gulch on, **150**
Characteristic shore-line on, **150**
coast scenery, **344**
Cocoanut Island, **150**
'Crater lake' on, **160**
Distances on (*see* Overland Distances)
Districts on, **148**
elepaio, **337**
Elevations on indicated, **148**
Fishing scenes in, **344**
Forest scenes on, **200**
General views on, **154**, **156**, **160**, **162**
half-bill, **332**
Hamakua, **150**
Hanging valleys on ,151
High flumes on, **274**
Highest point on, 147
Hilo Bay, view of, **352**
Ice on mountains of, 151
Island of, 147
Kilauea on, **166**
Kohala range on, 149
Kona district on, 182
Landing at Laupahoehoe, **154**
Lava boulder on, **160**
Light-houses on, **148**
Livestock in, **282**, **287**
Map of, **148**
Map showing recent lava flows, **148**
Mauna Kea on, **154**
Miscellaneous views on, **150**
Natural environment in, 9
Northeast coast of, **154**
No snakes in, 299
Number of peculiar plants on, **193**
Onomea arch on, **150**
Part in whaling industry, 303
Position of, **100**
Pele's journey to, 89
Points on, **148**
Ports and landings on, **148**
Pheasants in, 307
Rainbow Falls on, **160**
Rice in, 276
Rivers on, 147
Roads on, **148**
Scenery on, **150**, **156**, **170**
Sea-cliffs on, **154**
Sea-formed cliffs on, 150
Sea-snakes in, 299
Secondary craters on (indicated), **148**
Size and position of, 147
Snow on mountains of, 151
Spirit leaps on, 50
Stages in geological development of, **290**
Streams on, **148**

Steamship lines to, 100
Sugar production in, 275
Territory of, 99
Tropical fruits in, 255
Valleys on, 148
Vegetation on, 156, 160
Volcanoes on (indicated), 148
Volcanic scenery on, 156, 160, 162, 166, 170, 174
Waterfalls along the coast of, 154
Waterfalls on [Akala] (500 feet), 162
Waipio valley on, 154
Hawaii's Volcanoes, Work of, 163
Hawaiian a name language. The Hawaiian language is sometimes classed as a name language owing to the great number of name words it contains. Definite names were applied to almost every object in their environment.
Hawaiian (*see also* Native), 429
aquatic, 294
agriculture, 63
alphabet, Pronunciation of, 39
alphabet, The, 39
amusements, 74
Ancient gods of the, 49
armor, 79
arrow-root, 284
archipelago, Development of, 290
arts, 74
back-scratchers, 62
bark-cloth clothing, 38
bat, 295
bed, 72
birds becoming extinct, 338
birds, Common, 337
birds, Evolution of the, 338
birds, Extinct, 333
bird groups, 310
birds, Origin of the, 338
birds, Peculiar family of, 336
birds, Rare, 333
birds, Six interesting, 327
birds, Various orders of, 323, 327
broom, 62
boy, 32
bow and arrow, 81
Brownies, Work of, 359
burial cave, 52
cabinet wood, 211
candy, 210
carving, 59
children, 32
children, how dressed, 38
centipedes, 390, 407
checkers, 86
crickets, 429
coot [Alae keokeo], 323, 326
cosmetics, 215
crow [Alala], 327, 335
cub-shark [Mano], 340
Cytherea, 456
dialect, 27
dirge, 42
divers, 86
dogfish, 346
domestic animals, 295
duck [Koloa maoli], 323, 328, 335
Experiment Station (*see* Hawaii Agricultural Exp. Station)
edible mussel [Nahawele], 456
Entomological Society, Proc., 411
fans, 70, 62
flora, Striking plants in, 194
feudalism, 55, 56
fish baskets, 70
fish baskets and nets, 341
fish, Common, 366
fish, Curious, 366
fish, Species of, 351
fish traps, 70
fishes, 374
fishes (Part one), 338
fishes (Part two, 348
fishes, (Part three), 360
finch-like birds, 331
fireplace, 59
forest birds, 328
folk songs, 41
fortifications, 51
fruits, 264
Gallinule [Alae],323
games of chance, 86
girls, 32, 84
genealogies, 26, 41
goose [Nene], 310, 323, 335, 336
goose, food of, 255
group, Affinities of plants of, 193
group, Biologic evidence of subsidence of, 124
group, Geologic development of, 290
group, low islands of, 89
group, Position of, 100
group, Theory of formation of, 121
group, Stages in isolation of, 123
group, Submarine base of, 123
group, Subsidence of shown, 290
hawk [Io], 323, 327, 336
heralds, 53
herring [Makiawa], 350
honey-dew honey, 391
historians, 41
history, 41
house, 40, 56
house, Furnishings for, 56
implements, 74
Hawaiian igneous rocks (analyses of): Various samples analyzed by Dr. Washington exhibit the following variations in chemical composition given in per cent.
Class DOSALANE, including specimens of Andesite, Augite, Basalt, etc., contains: SiO_2 from 58.06 to 45.61; Al_2O_3 from 18.21 to 15.98; Fe_2O_3 from 8.25 to 2.23; FeO from 11.60 to 2.01; MgO from 4.85 to 1.59; CaO from 11.85 to 3.29; Na_2O from 6.12 to 3.50; K_2O from 2.80 to 0.80; TiO_2 from 5.35 to trace; H_2O from 0.27 to none; P_2O_5 from 0.72 to trace; MNO from 0.36 to trace; SO_3 from 0.20 to none; S from 0.05 to none; CuO from 0.05 to none; Sp. Gr. from 3.03 to 2.94.
Class SALFEMANE, including specimens of Basalt, Pele's Hair, etc., contains: SiO_2 from 56.79 to 47.61; Al_2O_3 from 16.09 to 12.10; Fe_2O_3 from 9.65 to 3.09; FeO from 11.97 to 2.61; MgO from 9.40 to 1.90; CaO from 10.25 to 5.92; Na_2O from 5.95 to

2.98; K_2O from 1.80 to 0.30; H_2O from 1.19 to none; TiO_2 from 3.97 to none; P_2O_5 from 0.76 to trace; MnO from 1.72 to 0.10; SO_3 from 2.54 to none; CuO from 0.48 to none; S from 0.02 to none; Cr_2O_3 from trace to none; Sp. Gr. from 2.93 to 2.74.
"INFERIOR ROCKS", including specimens of tuffs, ashes and decomposed rocks, contains: SiO_2 from 50.00 to 4.54; Al_2O_3 from 41.35 to 12.10; Fe_2O_3 from 40.87 to 7.82; FeO from 8.20 to trace; MgO from 11.75 to 0.37; CaO from 13.39 to trace; Na_2O from 5.23 to trace; K_2O from 1.77 to trace; H_2O from 1.87 to none; TiO_2 from 8.99 to trace; P_2O_5 from 1.25 to none; MnO from 1.13 to trace; CO_2 from 5.56 to none; SO_3 from 0.55 to none; CuO from 0.14 to none; S from 0.14 to none; FeS 1.40 to none; CoO from 0.04 to none; sp. Gr. from 2.80 to 2.77.
Hawaiian Islands, Climate of, 31
Bird Reservation, 93, 94
Extent of, 93
Geography of, 89-188
Geology of, 89-188
Leeward islands of, 88
Pilsbry theory of isolation of, 121-124
Principal ports in, 100
Position of, 100, 93
Temperature in, 33
Topography of, 89-188
Jew's harp, 83
land shells, Important genera of, 448
language, Character of the, 39
language, The, 39
language, when first written, 39
legends, 41
lips (characteristic), 38
lobster, 468
mahogany [Koa], 194, 211
markets, 74
medicinal plants numerous, 79
medicine, 79
medical diagnosis, 79
method of cooking birds, 324
method of embalming, 223
mistletoe [Kaumahana], 214, 225
keeper [kahu], 57
kissing bug, 402
mirror, 62
Middle-aged, 60, 68
moon flower, 202
modern music, 42
mountains, Ice on, 151
mouse, 295
napkins, 62
nose of (characteristic), 38
ornaments, 38
Old, 25, 60
oyster [Pioeoe], 456
people and their natural history, 86
Ancestors of, 26
Bearing the names of, 37
Giants among the, 37
Height of, 37
Literary efforts of the, 41
Note on text on the, 11
Personal appearance of the, 37
Physical characteristics of, 24, 37
Point of origin in the, 26
Stature of, 37
The (Section one), 25-87
Hawaiian perfumes, 21
pillow [uluna], 57, 62
pipe, 284
poets, 41
poetry, Example of, 41
poltice, 79
race, Development of, 31
race, Early and later conditions compared, 31
race, Early immigration of, 26
race, Early records how preserved, 41
race, establishment of, 30
race, Progress of, 31
race, Transformation of, 31
rats, 291
rays and sharks, 340
red birds, 329
reefs, 485
reef at low-tide, 472
rail [Moho], 327
rice, 276
rubber, 283
salt, 73, 129
sanctuaries, 51
seal, 294, 303
sharks and rays, 340
shore birds, Groups of, 310
short-eared owl, 336
singing, 42
soap (plant), 204
songs, 41
spearing fish, 344
sponges, Common, 494
spoon, 62
starch, 284
stilt [Kukuluaeo], 310, 327, 325
stormy petrel [Oeoe], 323, 309
sword, 81
temples of refuge, 51
tern [Noio], 310, 316, 323, 311, 318
tern, Colony of, 316
thrush [Omau], 334, 331
tobacco, 284
traditions, 41
tools, 74
top shell, 460, 466
traveler, 68
type, 68
white ant, 425
woman, 60
women's dress, 38
words when first written, 39
youth, 80
Hawaiians, adornment of, 38
An appreciation of, 31
and the struggles for existence, 45
as native people, 31
at home, 84
attachment for children, 45
Betting among, 86
Characteristics of (*see also* nose, hair, eyes, etc.), 31, 38
Cleanliness of, 38
Color of, 38
Corpulency among, 38
Clothing of, 38

Descent of rank among, 46
Division of labor among, 59
Early achievements of, 27
Early Settlement of, 26
excelled in tapa making, 77
Exchange of wares among, 74
Eyes of (Characteristic), 38
Features of, 38
Family discipine among, 45
Feudal organization of, 47, 54
Hair of, 38
Habits of, due to environment, 39
ideal of personal beauty, 38
ignorant of continents, 27
Infanticide among, 45
Insane among, 45
Large skeletons of, 38
Life of, in the open, 39
Long voyages of, 26
Lyric talent of, 42
Marriage among, 42, 45
Nose of (Characteristic), 38
Old, **84**
Old age among, 45
Occupations of, 63
Political development of, 31
Polynesian affinities of the, 25
Polynesian ancestry of, 25
Physical conditions effecting, 36
Rank and position among, 54
Religion of the, 47
Separation among, 45
Sex relations among, 42
Tattooing among the (*see also* Tattooing), 38
The chiefs and common people among, 38
The culture of the, 31
the first settlers, 25
their methods of warfare, 47
Traditions of origin, etc., 26
Types of old, **24**
Use of material at hand by, 75
Use of whale-ivory by, 302
Hawaii-nei, Position of, 101
Hawk, Hawaiian, **323, 327,** 336
-moth, 421
Hawks-bill turtle, 300
Headfish [Apahu], **374,** 358
Heart-shaped clam, 446
-shaped urchin, 487
shell, **456,** 446
"Heart's desire," The land of, 231
Heat cracks at Kilauea, 179
Popping corn over, **184**
Hebrew cone, **460,** 455
Hedge, Cereus, 254
plants, 251
Hei [Cat's cradle], which *see*
Heiau. Usually meaning a large temple of idolatry among the Hawaiians, but it was also the name of the house for the gods in every man's regular establishment, as well as for the small secret enclosure in the large temple.
Heiau at Kawaihae, Entrance to, **48**
Iliiliopai, on Molokai, **140**
of Mookini, 343
of Puukihola, **48**
pyramidal type, **48**
Heiaus, 50
dedicated to special gods, 50
Fish, 339
Milo in, 203
Number of, 50
The priests for, 50
Heii (tree fern), **190,** 194
Helmet [Mahiole], **44** 77, 333
shells, 461
Heliotrope, Beach, **192,** 199
Helix, 439
He makau (*see* fish-hook)
Hemerobians, 424
Hemispherical scale, 391
Henshaw, Prof. Henry W. (Biologist), 12, 14, 299
Hepatica, **214**
Hepaticæ. In 1877 D. D. Baldwin enumerated 73 species. Dr. C. Montague Cooke and others have added several species since, bringing the total up to near one hundred.
Heralds, Hawaiian, 53
Heralds' horn shells, 464
Herb. A plant not woody above the ground, if at all.
Herbert, Allen (Agriculturist), 445
Herbivorous (365). Feeding upon vegetable matter.
Hercules' club, 252
Hereditary poets and historians, 41
Hermit crab, **474,** 471
crabs, House-hunting by, 471
shell, **460**
Heron, Black-crowned night, **310,** 325
Herring, 358
Hawaiian, **350**
Hevea, rubber, 283
Hia (*see* Aulima)
Hibiscus, 213
Cotton related to, 281
Cultivated, 251
Varieties of, 251
Hides and tallow, Animals slaughtered for, 287
Higgins, J. E. (Horticulturist), 12
High chiefs, how buried, **52**
mountains, Plant life of, 210
points on Oahu (indicated), **110**
-tide, The reef at, **478**
Highest mountain in the Pacific, 147
Height of Hawaiians, 37
of Polynesians, 37
Hihimanu (Spotted sting ray), **340,** 347, 349
Hihiwai, **436**
Hihiwai, (Ham shell), **456**
Hiliu. The sound produced by a shell trumpet.
Hiiaka, 41
Hillebrand, Dr. W. F. (Botanist), 189, 191, 195, 201, 208, 211, 306
Hilo Bay, Cocoanut Island in, **150**
Bay, Fishing scene in, **352**
Bay, Mauna Kea in distance, **352**

coast (fig. 4), **194**
coast, 151
coast at Laupahoehoe, **154**
described, 175
Distances from (*see* Overland Distances)
grass, 208, 286
grass, when introduced, 286
Hilu, 349, 359
Hilu lauwili (Wrasse fish), **370**
Hilu pilikoa, 354
Hinahina, **198**
Hinalea lauwili, 349, 359
Hind, 369
Hinnites, 445
Hipponyx, 462
Hipuapua=(Hipupua) falls, **140, 133**
Histerid beetles, 417
History of Diamond Head, 219
of Oahu, 219, 220, 221
of Kilauea, Condensed, 183-188
of Mokuaweoweo, 155-163
of the eruptions of Mauna Loa, 155
Historians, Hawaiian, 41
Hitchcock, D. Howard (Artist), Painting of Halemaumau, Plate 47, No. 2
Hitchcock, Prof. Charles H. (Geologist), 12, 101, 115, 119, 120, 152, 153, 155
Hoary Head range, 105
Hoawa, **212, 220**
Hog louse, 400
Hog plum (*Spondias lutea* Linn.) or golden apple of Jamaica or Jamaica plum is rare in Hawaii although cosmopolitan in the tropics. It is a tall tree with yellow ovoid fruits sometimes 2 inches long, and odd-pinnate leaves in panicles 6 inches to a foot long.
Hogs, 287
teeth bracelets, 82
Wild, 295
Hoi (Black mamo), 335
(Yam), 213
Hoilo. The season of the year answering to winter in the northern latitudes. The opposite season or kau was the hot summer season.
Hollyhock, 281
Holoku or dress, **32, 60**
Home life of (*see* species in question)
scene, Hawaiian, **84**
Honaunau, City of refuge at, **48**, 182
Honey, 391
Algaroba, 243
bee, 404, 415
dew, 381
dew, secreted by, 391
-eater, Laysan, 314, 320
-eater, Yellow-tufted, **330**
Honu (Green turtles), **294**, 299
Honuapo, Road from Kilauea to, 182
Honohonowai (often contracted to 'honohono'). The name of the day-flower (*Commelina nudiflora* Linn.), a representative of the spider-wort family, sometimes called spider-wort, bearing small blue irregular flowers. Growing on alluvial banks and moist places throughout the group. This American plant with jointed, creeping, often branching stems, bearing parallel nerved leaves with sheathing petiole is much used as feed for livestock.
Honolulu as the center of the group, 101
Appearance of, 231
compared with Kew Gardens, **232**
First impressions of, 231
flower, Hibiscus as the, 251
gardens, Blossoms from, **250**
garden, Ramble in a (Part one), **231**
garden, Ramble in a (Part two), **243**
gardens, Views in, **240, 246**
harbor, 109
statue, The, **44**
Streets of, 232
Name derived from, 211
to various island ports (*see* **Distances**, etc.)
to various Pacific ports (*see* **Ocean** distances)
Position of, **110**
Honomu, 176
Akala falls (500 ft.) in, **162**
Hook, Fish (*see* fish hooks)
Shark, 343
Horn-worm, Sweet-potato, 399
Horned helmet shell, 461
Horned-nut, Chinese, 285
-pout, 377
Hornets, 414
Horse Cassia, 244
chestnut, 283
-hoof shells, 462
-weed, **212**
Horses, 287
introduced, 295
Horn fly, 387, 419
shell, **470**
Horse bot-fly, 387, 421
-hoof shell, **470**
Sea, **350**
Hotel at Kilauea, **166**
Horticulture, Enemies of, 381
Host. An animal or plant upon which a parasite habitually lives.
House, A temporary, **40**
cockroaches, 428
fly, 387, 419
fly parasite, 387
for idols, 58
for isolation, 58
foundation for a, 58
furnishings, 59
lizards, 297
Men's eating, 58
mouse, 293
Rethatched, 59
Sleeping, 58
spiders, 409
Thatching for a, 59
The building of a, 58
Timbers used in a, 58
Time employed in building a, **59**
Women's eating, 58
Household implements, 61
pests, 405
pets, Spiders as, 410
utensils, 56
How to collect algæ, 500
Hu (*see* Top spinning)

Huahekili (Hua=egg, hekili=thunder). A "thunder egg"; a hailstone. It generally thunders during hailstorms in the mountains of Hawaii.
Huahua akai, 479
Huakai. Hua, foam of the sea, hence a sponge.
Hualalai, 152
Eruption of 1801, 152
Position of, indicated, **148**
Hue, **490**
Hukaa. A general name for pitch, resin or gum from a tree.
Hula. A term applied by Hawaiians to music, singing and dancing. The dance took many forms, usually, however, a few danced while others sang and played instruments. The hula god was Laka (*see* plate 15).
ala'a papa (stanaz from), 41
anklets, **78**
dancer, **40**
dancers, Six, **78**
drums, 82
drum, Gourd, **57**
drum heads, 346
drum [pahu hula], Large, **64**
drums of cocoanut wood, **70**
girl, **78**
musicians, **78**
Musical instruments for the, 82
skirt, 82
The, 81
The profanation of the, 82
Translation of stanza from, 41
Hulas, 41
Huli, The, how planted, 65
Hull of a canoe, how made, **80**
Humahuma, 375
nukunuku a pua'a, 375
Human hair, Leis of, 79
hair, use of, 81
flea, 401
sacrifice (*see* Sacrifice)
teeth as ornaments, **70**
Humming-bird moth, **398**, 399, 421
Hump-backed cowry [Leho], **460**, 458
Humpback whale, 301
Humuhumu nukunuku apua'a (Trigger fish), **370**, 349
Hunting land shells, 437
-spider, 409
Hut built on Green islet, **90**
Hybrid pheasants, 308
Hydra, Fresh water, 475
Hydrocorallinæ, 481
Hydroids, 475, 480

I

Iako (part of outrigger), **80**
Ianthina, 464
Iao valley (Maui), **134**
valley, 138
Ice on Hawaiian mountains, 151
Ideal of personal beauty among Hawaiians, 38
Idlewild, 141, 143
Idol, **57**
Idolatry, 49
Idol, Moorish, **370**, 361
Small, **57**
Wooden, **52**
worship, 49
worship and fishing, 73, 339
Idols carved from, 211
House for, 58
how disposed of, 52
of wood and stone, 49
used in warfare, 53
worshiped by fishermen, 73
I'e defined, 339
Ieie, **190**, **202**, 211
Natural habit of, **190**
roots, Use of, 77
Uses of, 211
vines, Natural habitat of, **200**
Ie kuku (*see* Tapa beaters)
Iheihe (Half-beak), **350**, 349, 358
Ihi. The name of the pigweed (*Portulaca oleracea* Linn.), the roots of which were used in native medicine as a mild cathartic.
Ihi (Purslane), **196**
Iholena. A variety of banana which was permitted to be eaten under the *kapu* system.
Iholena, 259
Iiwi, **334**, 329, 430
Use of feathers of, 77
Iliiliopai, Heiau of, **140**
Information about **60**
Iliiopoi (*error see* Iliiliopai)
Ilikala. The name of the rough shark skin fastened over a cocoanut shell to form a drum.
Iliki. A kind of varnish made of kukui bark, etc.
Ilima, **192**, 203, 209
lei, **78**
Species of, 209
uses of, 209
Ilioha=Iliohe
Iliohe (Fleabane or horse-weed), **212**, 287
Illuminating oils, 62
Illustrations, Credit for, 14
Number of, 7
Immigrations, Early, 26
Immigrant. A species occurring elsewhere but having reached the islands by natural means.
Implements, Hawaiian, 74
of stone, bone and wood, 74
of warfare, 79
Important economic insects (Part one), 380
economic insects (Part two), 391
food fish, 348
Imu. A place for baking made by heating stones under ground (*see* plate 4).
Imu, 210
how made, 66
Shells cooked in an, 465
Ina, 485
eleele, 485
keokeo, **496**, 485
liilii, **496**
Inamona. The meat of the kukui nut, roasted and pounded up with salt, used as a relish at table.
Incas of Peru, 293

Index to glossary, Note on the, 10
India, 219, 221, 225, 242, 245, 276, 296, 369, 400, 407
cotton boll worm, 400
Pride of, 244
rubber tree, 245
Indian date, 245
licorice, 207
shot, 207
shot, uses of, 207
Indigenous grasses, 286
Indigo [Inikoa], 212, 207
Uses of wild, 207
When introduced, 207
Indo-China, 263
Industries, Agricultural, 270
Coffee, 279
New, Cassava, 284
New, Castor bean, 285
New, Fiber, 284
New, Peanuts, 285
New, Rubber, 281
New, Sisal, 280
New, Tobacco, 283
Potato, 284
Rice, 284
Sugar, 284
Tropical (*see* Sugar, coffee, rice, etc.)
Industry, Animal, 287
Chief, 271
Infanticide, 45
Explanation of, 45
Infantile paralysis transmitted by, 419
Inferior rocks (*see* Hawaiian igneous rocks)
Inflorescence. The arrangement of the flowers on the stem.
Inflorescence, Deformed, 220
Diseased, 202
Inhabited islands, 100
islands, The, 101
islands, Position of, 101
Iniko (*error see* Inikoa)
Inikoa (Indigo), 212, 207
Injurious plants and animals, how introduced, 271
Ink, Squid (*see* Pikopiko)
"In Memory of Keeaumoku" (dirge), 42
Insane among Hawaiians, 45
Insect cabinets, 380
fauna, Character of native, 411
fauna (*see* Total insect fauna)
Insectory, Interior of an, 380
Insects affecting (*see* plant in question)
Collecting of, 380
Common, 392, 398
Conspicuous Hawaiian, 392
Control of by, 381
Curious, 392
Economic (Part one), 380
Economic (Part two), 391
Familiar, 392
groups not yet studied, 412
Highest order of, 412
important destructive species, 380
Injurious introduction of (*see* species in question), 387
Lantana, 383
Lowest living order of, 430
on Mamaki, 411
Native, 440
Native and introduced, 392
Nerve-winged, 423
Some economic, 384
Study of, 380
Sugar-cane, 388
Two-winged, 419
Inside of Haleakala, 145
Insigna of rank, 75
Instrument, Modern [ukulele], 78
Intensive study of mamaki insects, 411
Intercourse resumed with Polynesia, 27
Inter-island channels, 100
Inter-island channels. Width of: Oahu-Molokai [Kaiwi], 23 miles; Molokai-Maui [Pailolo], 8 m.; Maui-Lanai [Auau], 7 m.; Hawaii-Maui [Alenuihaha], 26 m.; Oahu-Kauai [Kaieie Waho], 63 m.; Kauai-Niihau [Kumukahi], 15 m.
Inter-island channels (*see* Depths of)
Inter-island distances by sea (*see* Distances, etc.)
Inter-island variation in flora, 193
Intoxicating drink [Awa], 216
[Okolehau], 210
Intrigue among chiefs, 55
Introduced. A species imported by man.
Introduced and native fruits, 264
animals, 231, 295
birds, 304
fish, 376
fruits, 255
grasses, danger from, 286
plants, 205, 231
plants, Effect on native flora of, 205
plants ,Escaped, 200
When (*see* species in question), 296
Introduction of birds, 320
of destructive insects, 380
of leaf-hopper parasites, 382
of plants, 283
of sugar-cane, 271
Invisible double, 49
Io (Hawaiian hawk), 323, 327, 336
Ioli, 291
Ipecac, Wild, 212
Ipu. The general name for all kinds of gourds, calabashes ,etc., and for containers of any kind made from them.
Ipu, 209
hula (Gourd drums), 78
nui, 209
Ipu Lono. The name egiven to a certain class of small heiaus built in order to induce rain in time of drouth. The same term was applied to a sacred calabash kept in private houses in which offerings were made to the family gods.
Irish potatoes, 284
Ironwood, Australian, 237
Irrigation ditches, 27
flume (high), 274
flume, Modern, 28
of taro, 270

Isabella cowry, 470, 459
grape, 267
Island fruits, 255
Gardner, 88
Hawaii, 147
Kauai, 88
Kaula, 88
Kahoolawe, 132
Lahua, 88
Lanai, 132
Laysan, 88
Lisiansky, 88
Maui, 132
Midway, 88
Molokai, 132
morning-glory, 197
Necker, 88, 96
Nihoa, 96
Niihau, 88
Oahu, 88, 109
Ocean, 88
The pan-Hawaiian, 290
Islands, Leeward, Elevations of, 93
Shoals, etc., Map of, 88
The inhabited, 100
Isolation of fauna graphically explained, 290
of flora graphically explained, 290
Isthmus of Maui, 139
"Neck of Maui," Example of, 134
Itch mite, 401
Ivory and tortoise shell, use of, 60
fishhooks, 242
necklaces, 79
hook [palaoa], 60
Ivy scale, 391
Iwa (Man-o'-war bird), 310, 77
Iwaiwa, 223
Ixora, 249
Ixora named for, 249

J

Jack fruit (*Artocarpus integrifolia* Linn.). A tree belonging to the breadfruit genus, and having a milky juice. The leaves are 4-6 inches long and are variously shaped. The fruits, which are usually oval, are often enormous, occasionally weighing 50 pounds. They occur on both the trunk and branches. The green rind resembles the breadfruit in being covered with rough six-sided knobs. The pulp is seldom eaten owing to the offensive odor. This tree should not be confused with the durion (which *see*).

Jam, Guava, 263
Poha, 257
Jamaica, 244, 296
Jambosa (*see* Ohia ai)
Jamestown weed (Jimson weed), 198, 287
Japan, 236, 266, 296, 297, 308, 345, 346, 360, 376
Japanese beetle, 394, 415, 417
beetle, Enemies of, 384
beetle on grape, 267
flower peddler, 246
goldfish, 376
grass, 287
palm, 237
pheasant, 307
plum, 266
poachers, 95
Jasmine, 248
Arabian, 248
Snow-white, 248
Spanish, 250
Jassids, 427
Java, 207, 279, 280
plum, 268
Javelins, 79
Jelly, Guava, 263
Jellyfish, 475, 480
Jew-fish, 369
Jimson weed [Kikania] (*see* Jamestown weed), 198, 287
Jingle shell, 456
Job's tears, 198, 207
Uses of, 207
Journey to Kilauea, 175
Judd, Dr. A. F., 286
Judd street cave, 129

Jujubi (*Zizyphus Jujuba* Lam.). Occurs in Hawaii, having been introduced originally from China. The small tree is characterized by thorny branches and triple-nerved leaves, which are alternate, 1-3 inches long, green above and nearly white beneath. The small axillary flowers are followed by the fruits, which are about the size of a cherry and yellow-green when ripe and bitter to the taste; they make excellent preserves. Several varieties are grown in China and India and more than one occurs in Hawaii; one is known as the Chinese date.

Jumping-spider, 409
Jumping the rope, Game of, 86
Jungle, Fern, 194

K

Kaala, 132
Vision point of the group, 132
Kaapeape, 228
Kaawau, 214
Kadua (*see* Kopa)
sp., 220
Kaena Point, 109
Surf at, 122
Kaeo, the high point on Niihau, 101
Kahala (Amber fish), 362, 349
Kahana a drowned valley, 131
bay, 128, 211
bay, Natives fishing at, 344
Kahiki, 27
Useful plants and animals brought from, 29
Kahili (fly-flap), 60
"Kahili" Lobelia, 224
Kahilis, 57, 77
how made, 77
Small, 60, 70

Kahoolawe was for a time used as a place of exile for state offenders. The only article of food produced on the island at that time was sweet potatoes, in a small quantity.

Kahoolawe, 135
Area of, 237
Island of, 132
Position of, 100
Rats on, 291

Kahoalii (*see* Opelu tabu)
Kahu, 57
Kahuku Point, 109
Kahului Bay, 138
Distances from (*see* Overland Distances)
Kahuna. A general name applied to such persons as have a trade, an art or practice or profession. Some qualifying term is generally added, but in Hawaiian antiquities the word *kahuna* without any qualifying term refers to the priest or person who offers sacrifice.
Kahuna(s), 54
An aged, 52
and the tabu, 46
doctors, 79
Kahuna lapaau (Medicine men).
Kailua Bay, 211
Kaimuki, 115
Kaiulani's flower, 248
Kakonakona, 209
Kaku, 349
Kala, 372, 349
Kalaipahoa (Poison god), 70
Kalakaua, Coronation celebration of (hula), 78
Kealakekua Bay, 182
Kalalau valley, 108
Kalau=Kilau
Kalauhauoni peak (3282 ft.) [Kalawao], 136
Kalaupapa, 135
Landing at,134
Kalawao, 135
Kalauhauoni peak shown, 136
Leper Settlement, 134
Olokui (4600 ft.) in the distance, 136
Kalia. A common tree (*Elæocarpus bifidus* Hook. and Arn.). Its flowers are stung by an insect (*see* plate 56) which causes them to be deformed. The red growth is sure to attract attention.
Kalia, 202
Kaliumaa, 131
Kaluha (Nut grass), 196, 212
Kamaa (Sandals). Sandals made of lauhala leaves, etc., were worn when traveling on rough lava and similar places in the open country.
Kamakahala. A name applied to several species of Hawaiian plants belonging to the same genus (*Labordea* spp.), but especially to the yellow flowered species on Molokai and Oahu. Leis made of these sweet-scented flowers were tabu to the common people, being reserved for the use of the high chiefs alone.
Kamakua peak, 133
Kamalo, Cloud cap over, 142
Mountain of (Molokai), 142
Kamani, 59, 201, 222, 245
grove, Sacred, 140
Native, 248
Kamau, 337
Kamehameha butterfly, 392, 421
Brig, 97
Kamehameha I., 211, 221, 281, 295, 343
Feather robe of, 75
on conservation, 221
Statue of, 44
Kamehameha III., 300
Kamehameha V., 266
Kamole. The name of a plant (*Polygonum glabrum* Willd.) common about taro patches and running water extending its rang along the water courses and swampy land well into the mountains.
Kamole, 212
Kanae valley, 144
Kanaka (Pacific islander), 25
Kanaloa, 49
Kanapi. Hawaiian for centipede.
Kanawau, 224
Kane, 49
Kaneohe, 115
Bay, 211
craters, 121
Kao (fish spear), 344
Kapana, 214
Kapena nehu, 341
Kapiolani breaks the spell of Pele, 171
Park, Drive in, 234
Kapoho, 176
Kau (*see* Hoilo)
Kau, 183
Hawaii, Dodder in, 205
The summer season (*see* Hoilo)
Kauai, 103
Age of (shown by erosion), 106
akialoa, 330
Amakihi, 334
Boys on, 104
Coast line of, 103
Cañons on, 102, 104, 107
Capes on, 104
Coral reefs about, 103
Description of, 101
Distances on, 104
Distances on (*see* Overland Distances)
Districts of, 104
Examples of erosion on, 106
Geologic development, 290
Hanalei bay, 102
Hanalei river on, 106
island, 88
Lighthouses on, 104
Map of, 104
Miscellaneous views on, 102
Number of native plants on, 193
Olokele cañon on, 106
Points on sea-coast, 104
Position of, 100, 104
Relief map of, 104
Rivers and streams on, 104
River view on, 102
Roads on, 104
Secondary craters on, 104
Secondary volcanic cones on, 105
Shore scene on, 102
Soil of, 105
Sperm whale on, 298
the oldest island, 193
thrush, 330
Topographic map of, 104
Towns and villages on, 104
Typical village on, 102

Valleys on, **104**
Village of Hanamaulu, **102**
Villages and towns on, **104**
Wailua falls on, **102**
Waterfalls on, **102**
Waimea cañon on, **106**
Kauila, 215
Native use of, **80**
uses of, 215
Kaula Island, **88**, 101
Kaumahana (Hawaiian mistletoe), **214**
Kaumana caves, 176
Kaunoa, **460**
Kaupo gap (Maui), **134**, 139, 144
Kaupu (Black-footed albatross), **227**, **319**
Kawaihae Bay, 149
Heiau at, **48**
Kawakawa (Little tuna or bonito), **366**, 349, 363
Kawalea (Barracuda), **366**
Kawau, **224**
Kawelea (Lizard-fish), **350**, 349, 359
Kealakekua Bay, **84**
Keanakakoi, a pit crater, **186**, 178
Floor of, **186**
Map of showing, **148**
Keauhou, Toboggan slide at, 182
Keke, 367
Kendrick, Capt., 219
Keona, 183
Kewelea, 353
Kew Gardens, Honolulu compared with, 232
Keyhole limpets, 466
wasps, 414
Kiawe (Algaroba tree), **240**
Kigelia (*see* Sausage tree)
Kihikihi, Moorish, **370**, 361
Kiholo. The name of a large kind of a hook formerly made of wood, used to catch shark and other large fish.
Ki, **190**, 59, 67, 221, 251
leaf skirt, **78**
leaves, uses of, 66
roots, use of, 210
(*see* Ti), 210
uses of, **190**, 210
Kikakapu (Butterfly fish), **370**, 349, 353
Kikania (Jimson weed), **198**
Kilua, 223
Kilau, **228**
Kilauapueo=Kilua
Kilauea, a bubble dome in, **186**
Activity of in 1902, 173
Activity of in 1907, 173
Ahanui at, **206**
an independent crater, 165
an exploded mountain, 167
Ascent of, 176, 177
Cavern in, **186**
Caves in, **170**
Condition at in 1823, 169
Condition of from year to year, 183-188
Condensed history of, 183-188
Dates of eruptions of, 183-188
Depth of, **170**
Descent into crater of, 178
Dimensions of, 165
Eruptions of, **174**
Eruption of 1789, 168
Eruption and flow of 1840, 172
Eruption and flow of 1892-94, 173
Examples of pahoehoe in, **184**
Explosive eruption at, 168
Fire lake in, **174**
First view of the crater, 177
flow of 1868, 159
General view of, **166**
"Great crack" in the floor of, **184**
Heat cracks at, 179
Hotel at, **166**
-iki, **170**, 178
Floor of, **170**
Map of, **148**
showing lava streams, **170**
Koa forest at, 181
Lava falls in, **186**
Lava floor of, **166**
Lava flows in, **166**, **174**
Lava mounds in, **186**
Lava pool in, **174**
Location of, 164
Map of, **148**
Model of, 173
Number of eruptions of, 169
on Hawaii, **166**
Pahoehoe flows in, **166**
Painui at, **206**
Pele, Goddess of, 91
Popping corn in, **184**
Rise and fall of lava in, 167
Ropy lava in, **186**
Scenes along the road to, **200**
Side trips from, 181
Spatter cones at, 179
Staghorn fern at, **194**
Steam cracks at, 177
Sulphur banks at, **170**, **177**
Vegetation at, **166**, **170**, **200**
Views in, **174**, **184**
Visit to in 1909, 175
Waldron's ledge at, **170**
Walls of shown, **184**
Killer, 301
whale, 346
Killifish, 378
Kilohana crater, 105
Kingfisher. A stray pair has been reported by Prof. H. W. Henshaw from Hilo. The skin of one of them is now in the Bishop Museum. They were evidently ocean waifs, as the pair mentioned constitute the only record of the occurrence of the species in Hawaii.
'King of the herring,' 358
of the mackerel, The, 358
Street, Government Nursery, **238**
The, and the land, 55
The, and the power, 54
The, and the tabu, 46
Kings, The, sacrifice, 51
Kiokio, 83
Kipahulu, Maui, 139
Kipi, **332**
Kipu kai, 199
Kirkaldy, G. W. (Entomologist), 425

Kissing bug, Hawaiian, 402, 426
Klu=Kolu, 198, 205
Knee-cap shells, 467
"Knife-edge" ridges (Koolau range), 130
Knife fishes (Surgeon fish), 372
Koa, 202, 59, 207, 211, 226
Curious 'leaves' of, 211
(Hawaiian mahogany), 194
False, 198
Native use of, 80
use of, 86, 211, 213
used in canoes, 29
Varieties of, 211
wood, Varieties of, 211
Koae (Tropic bird), 310, 259
Use of feathers of, 77
Koaia, 226
Koali, 197
Koali ai, 197
Koe (Marine worn), 490
Koebele, Mr. A. (Economic Entomologist), 385, 393
Kohala Mountains, Age shown by erosion (Waipio), 154
plantation, one of the first, 149
Promotory, an example of, 148
range, 149
range, small cones in, 149
Soil of, 149
spider, 410
statue of Kamehameha I., 44
Kohola (Humpback whale), 302
Kohola. A reef, a dry place; hence a whale from his spouting water like the water on the reef. The flesh of the whale was forbidden to women under the *tabu* system.
Kokio. The name of a native tree belonging to the *Malvaceæ* occurring on Molokai (rare) known as the native red cotton owing to its showy red flowers. The bark was used by the natives as a dye for fish nets.
Kokio, 281
Koko (plant), 283
(Calabash net), 68, 76, 59, 61
crater from Koko Head, 128
Head, 472, 115, 121
Kokolau, 220, 227
Kolea. A name applied to almost all of the several species and varieties of the genus *Suttonia* common on all islands.
Kolea, 226, 324
Kolea (Pacific golden plover), 310
Kolealea, 470
Koloa maoli (Hawaiian duck), 323
Koloa, Spouting horn at, 108
Kolokolo kuahiwi, 230
Kolu (Klu), 205
-bush moth, 397
Uses of, 205
Kona coffee, 279
thick-bill, 330
weather, 31
Konahuanui (3105 feet), 125, 114
Plants from summit of, 224
View of, from Olympus trail, 206
Konane was a checker-like game played usually on the flat surface of a slab of sandstone or lava rock in which a varying number of small depressions were dug out to form the stations. Small black and white stones were used for the counters in the game (*see* Hawaiian checkers).
Kookolau=Kokolau
Kookoolau=Kokolau
Koolau gap (Maui), 134, 144
mountains, 211
mountains, Age of, 124
mountains ,Early appearance of, 220
range, 114, 132
range, Erosion of shown, 112, 130
range, mountains in the, 112
range, Structure of the core of, 125
Kopa. A shrub (*Kadua* spp.) the fruit of which is made into beads.
Kopiko. Name of a tree (*Straussia* spp.) the wood of which was used for the *Kua* or anvil in making tapa; it is also a good firewood.
Kopiko, 202, 220, 226
Kou, 198, 59, 61, 63, 201
Krauss, Prof. F. G. (Agriculturist), 12, 276, 281
Kukailimoku, the god of war, 52, 77
Kukai neenee, 256
Kukuluaeo (Hawaiian stilt), 327
Kukui (Candle nut tree), 202, 210, 226, 239
a recent arival, 239
gum, 239
leaves, use of, 65
nut, 57
nut leis, 57
nuts, use of, 62, 71
Wood of the, 239
Kumimi, 469
Ku, 49
Kua kuku (Wooden tapa anvil), 64
Kualoa headland, 111
Kuhns Bros., D. B. and J. M., 447
Kuhns, D. B., 12
Kukaepuaa, 286
Kumquat (*Citrus Japonica* Thumb.) or kin-kan, is a native of China, or Cochin China, but it has long been known in Hawaii. The fruits are small, round or oval, and are orange-like in appearance. In America it is coming to be prized as a preserve; the sweet rind and the pulp may be eaten raw. The Chinese make excellent preserves of the fruit. Only the attacks of insect pests prevent this fruit from more general cultivation in the islands. The rich green dense foliage makes a truly ornamental as well as useful tree.
Kumquat, 265
Kumu (Goat-fish), 362, 349, 373
Kupakala (Rock oyster), 456, 446
Kupaoa. A plant (*Raillardia scabra* D. C.) used to scent tapa.
Kupaoa, use of, 71
Kupee (sea snail shell),470
Kupee, Wrist ornament of, shells, 470
Kupipi, 349
Kupikipikio, Map showing, 118
Kupua. A sorcerer: a person of extraordinary powers of body or mind. Sorcerers, wizards and witches are frequently spoken of in Hawaiian antiquities in their *kaaos* and *melea* as things that existed and were fully believed in.

Kupoupou, 349
Kupukele, 444
Kusaie banana, 259
Kuula, a fish god (*see* Shark god)

L

Laau. A general name for what grew out of the ground, but often used as the name of medicine. The ancient Hawaiian medicines were numerous, and consisted mostly of mixtures of leaves of trees, bark, roots, etc. Some were excedingly nauseous, while other were very acrid, but the physicians depended more on their enchantments, their invocations to the gods and to the sacrifices offered, than to the virtue of their medicines as such.
Laau, 221
Laborers, Plantation, **274**
Labroid fishes, 359
Lace-winged fly, Common, 424
Ladder shell, **470**, 464
Ladybird beetles, 393, 416
beetles, Australian, **384**
Lady-bugs, 416
Lady-fish, 354
Lae, 349, 364
Laeloa craters, Age of, 124
Lagoon on Laysan Island, **316**, 95
Lahua Island, **88**
La-i (Lauki), 210
Laie, 131, 211
Laka, Goddess of the hula, 82
Lake, Green, on Hawaii, **160**
Lama. The name of a forest tree (*Mabu Sandwicensis* A.DC.) common on all the islands of the group. Its very hard wood was much used in building houses for the gods and always occurred as an alter piece in the worship of laka, the goddess of the hula. The reddish-yellow berries and thick, leathery, dull green alternately arranged leaves are conspicuous characters.
Lamb tree, The, 281
Lamellibranches, 443
Lamellicorn beetles, 417
Lamp-shells, 483
Lamps [Kukui] of stone, **70**, 62
Lanai. A bower, a shed, a piazza, a porch. The term is in very general use in Hawaii being applied to any form of an open structure intended for shelter.
Lanai, 135
Dimensions of, 135
Highest point on, 135
Island of, 132
Map of, **134**
of palm leaves, 236
of hau, 201
Position of, **100**
Lananuu (*see* Oracle)
Lance-fish, 372
Lanceolate (227). Shaped like a lance.
Land belonged to the king, 54
and the king, 55
fauna, Isolation of graphically explained, **290**
fresh water and marine fauna (*see* Total land, etc.)
shells, 431
shells ,Color variation in, **432**
shells, Important families of, 437
shells, Important genera of, **448**
shells, Significance of, 121
shells, use of, 77
slide of 1868 ,159
Sugar, 271
titles, 55, 56
tortoise, Galapagos, 300
Various animals from, 291
Landing a sea net, **334**
Landings (*see* Bays, etc.)
Lanihuli peak (2781 feet), **112**, **125**, 114
Language, Hawaiian, Character of, 41
The Hawaiian, 39
The Polynesian and Hawaiian, 39
Lantana, **198**, 205, 209
blight, 385
bug, 426
butterflies, 385, 421
-fly, 419, 427
gall-fly, 385
Imported enimies of, **384**
insects, 383
Introduction of, 383
leaf-bug, 385
leaf-minor, 385
scale, 385
seed-fly, 383
plume-moth, 383
Lantern, Aristotle's, **496**
fishes, 359
Lapalapa, **224**
La Perouse, Compe de Jean François (Navigator), 97
La Platte tobacco, **192**
Largo banana, 259
Larvæ (299). The early stages in the development of any animal in which it is unlike the parent in appearance.
Lasso cells, 480
Last eruption on Maui, 147
human sacrifice (*see* Sacrifice)
Lateral band or line (351). Along the sides of a fish is a line of peculiar scales called the lateral line.
Lateral craters on Maui (indicated), **134**
Latitude in the Pacific, **100**
Latex defined, 283
occurs in ,283
producing trees, 283
Latin names, why used, 10 (*see also* Nomenclature)
Lauhala, **194**, 59, 204, 211
fruits, Uses of, 204
leaf skirts, **78**
mat, **57**
mats, how made, 72
mat, Materials for, **60**
mat, Plaiting of, **60**, **84**
nuts, 204
trees, **150**, **190**
use of, 81, 204, 221
Lauia, 349
Lauki (La-i), 210
Laupahoehoe, Hawaii. Landing at, **154**
Hilo coast at, **154**

Lava around trees in Puna, **156**
brick, 129
boulder on Hawaii, **160**
column, height lifted, 164
discharge, 1907 flow, 163
floor of Kilauea, **166**
flow, General view of, **162**
flows in Kilauea, **166, 174, 186**
'flower pots,' Puna, **156**
flows, Recent, on Hawaii, **148**
Flow structure of, **186**
flow, Surface of, **160**
forms of (curious), **186**
mound in Kilauea, **186**
'pillars' (Puna), **156**
pool in Mokuaweoweo, **186**
Rise and fall of, 167
rock as building stone, 129
soil, 107
Solidified (recent), **166**
tree casts in Puna, **162**
tree moulds (Puna), **156**

Lavas of Hawaii and their Relations. Under the above title Dr. Whitman Cross discusses the Hawaiian rocks in an exhaustive and able paper (Professional Paper 88, U. S. Geol. Survey, 1915) to which the technical student of Hawaiian lavas is referred for detailed information bearing on the composition, classification and theoretic problems involved in a study of this subject.

Law of custom, 55
Laysan albatross, **92, 294,** 312
albatross—the end of the dance, **316**
Bird life, Views of, **310, 316**
canary, 314, 319, 320
canary as cage bird, 319
canary nest and eggs, **316**
Discovery of, 95
duck, 318
honey-eater, 314, 320
rail, 314, 318
Laysan Island, 95
Birds of, 312
Description of, 313
General view on, **92, 316**
Guano on, 95
Harbor at, **92, 95**
Manager's quarters at, **92**
Position of, 88
Rabbit on, 293
Salt-water lagoon on, **316**
Struggle for existence on, 313
Views on, **92, 294**
Leadwort, 254
Leaf, A falling (palm), 232
-cutting bees, 415
-miners, 423
-miner beetle, 419
-hoppers, 388, 427
-hopper, Sugar-cane, 381
-hopper, Sugar-cane, Parasites of, 382
rolling moths, 395

Leaflets. One of the divisions or blades of a compound leaf.

Leahi (*see* Diamond Head), 115
Lealoa, 115
Leaping place of ghosts (*see* **Jumping off places**)
off places for spirits, 53
Lechoso (*see* Papaya)
Ledyard, John (With Capt. Cook), **153**
Leechee (*see* Lichi)
Leeches, 440, 497
Leeward chain, Map of, **88**
(Midway and Ocean Islands), Views on, **90**
Miscellaneous views from, **96**
Leeward Islands, 93
Elevations of, 93
Formation of, 93
Geologic history of, 93
Number of, 93
Legend and science agree, 91
Coming of Pele, 89
of Haleakala, 139
of Naupaka flower, 197
of Maui and the alae, 326
Leho, 455, 458
Leho (Hump-backed cowry), **460**
puupuu (Madagascar cowry), **470**
Lehua, 101, 216
Ohia, **220**
Lei, Feather, **57**
ilima, **78**
maile, **78**
or necklace of flowers, **32**
palaoa, **60**
Leis, 77
Black-eyed Susan, 207
Feather, 333
Kukui nut, **57**
of cone shells, 455
of dried fruit, 77
of human hair, 79
of nuts and seeds, 77
Seeds for, 204

Lelau. The name of a native banana of fine flavor.

Lele (Alter), 259
Lemon, 263, 264
scab, 265
guava, **264,** 263
Silvery, cause of, 265
Water, 268
(Water) Purple, **258,** 268

Length, Width, Area and Population of Hawaiian Islands (U. S. Census 1910): HAWAII—90 by 74 miles, area 4015 square miles, population 55,382; MAUI—46x30 miles, area 728 square miles, population 28,625; OAHU—46x25 miles, area 598 square miles, population 81,993; KAUAI—25x22 miles, area 547 square miles, population 23,952; MOLOKAI—21x8 miles, area 261 square miles, population 1791; LANAI—97 square miles, population 131; Midway population 35; total population, 191,909.

Leper Settlement, 135
Kalawao, **134**
Kalapapa Landing ,134
View in, **136**

Leprosy. This disease was introduced from abroad prior to 1853, probably about 1840. The policy of segregation was entered upon in 1863, the disease having become widespread by that date.

Lesser gods, 49
Lettered cone, **460**, 455
Lice, 400
Lichee (*see* Lichi)
Lichen (226). Plants of low order appearing in crusts, scaley patches and bush-like forms on trees, rocks, the ground, etc.
Lichens are found everywhere in the group on rocks, trees and the bare ground. Bailey (Thrum's Annual, 1887) records 136 species. The list could doubtless be extended by careful study.
Lichens in the rain forest, **194**
on citrus fruit trees, 265
Lichi, 269
Licorice, Indian, 207
Life history of (*see* animal in question), 499
plant-lice, 391
Light, Artificial, 62
Effect of, on birds, 311
Lighter load of guano, **92**
Lighthouses on Kauai, **104**
on Hawaii, **148**
at Laysan, **92**
on Oahu, **110**
Lilac wreath (Purple wreath), 248
Lilikoi (Purple water-lemon), **258**, 268
Liliuokalani (Queen), 48, 300
Lily, Palm, 210
pond (Ainahou), **234**
Lime, 129
Coral as source of, 475
Limes, 263, 264
Limestone, 117, 129
Limnæa, **436**
Limpets, 462, 466
Force necessary to dislodge, 467
Limu. The class name for seaweed (*see also* Pumice).
Limu, 500-503
as medicinal plant, 502
Common at Waikiki, **492**
eleele, 502
koha, **214**
kohu, 502
lipeepee, 502
oolu, 502
Linear (204). With parallel margins: narrow.
Lip [Mollusca] (452). The inner or the outer side of the aperture.
Lipoa, 222
Lips of Hawaiians (Characteristic), 38
Liquid lava, Rise and fall of, 167
Lisiansky Island, **80**, 95
Bird poachers on, 95
Discovery of, 95
List of Distributors (*see* Distributors)
Litchi (*see* Lichi)
Literary efforts of Hawaiian people, 41
Lithophyllum sp. (fig. 1), **498**
"Little Beggar" spatter cone, **184**, 180
emerald shell, **470**
sea snail, **470**
tuna or bonito [Kawakawa], **366**, 361, 363
Littoral flora defined, 195
Liver fluke, 299
Livestock, 287
Effect of, on, 287
in Hawaii, **282**
when introduced, 287
Lizard, California, 299
-fish [Ulae], **350**
-fishes, 359
Lizards [Moo], 297, 491
Change of color of, 297
Species of, 297
Loading cattle, **282**
guano, **92**
sugar-cane, **278**
Lobed (197). Cut into small lobes or rounded points.
Lobelia, **212**, **224**, 228
Fruit of flower of, **206**
Lobelias, Common, on Oahu, **206**
Genera and species of, 225
"Kahili," **224**
Typical, **224**
Lobster, 468
Hawaiian, **474**
how caught, 469
Location of Islands (*see* Position of)
Lochs, Pearl (*see also* Pearl Harbor), 115
Lohiau, 41
Loin cloth, 38
Loli, 493
kai, 493
koko, 493
pua, 493
Lolo, 359
Lolo-oau (Flying gurnard), **374**, 357
Lomilomi, use of, 79
Long-distance runners, 83
-horned beetles, 388, 395, 417
-horned grasshopper, 388, 429
-legged flies, 419
sea net, **344**
-tongued bees, 415
-tailed Crustæa, 466
-tailed field mice, 293
-tailed rat, 292
voyages by Hawaiians, 26
voyges, how made, 26
voyages, Provisions for, 29, 67
Longitude in the Pacific, **100**
Loopers, 397
Loquat, 266
Lotus, 285
Flower of, 285
Loulu. The name of the native palm (*Pritchardia*) of which ten species are now recognized by O. Beccari as belonging to the Hawaiian flora.
Loulu hiwa, 236
lelo, 236
Louse (*see* Lice), 400
flies, 421
Love birds, 318
whistle, 83
Low bushes on Ocean Island, **90**
islands of the group, 89

Lower forest and field plants 212
zone, 210
zone, Plants of, 202, 210
Lowland zone, 195, 201
Plant life of the, 189
Low-tide Fishing for squid at, 472
Hawaiian reef at, 472
Luakini. A heiau of the largest class.
Lucerne, 286
Lucina shell, 456
Lucuma (*see* Egg fruit)
Lycopersicum (*see* Tomato)
Lycopodiaceæ (*see* Club-mosses)
Lyric talent of Hawaiians, 42

M

Maalaea Bay, 138
Mabu (*see* Lama)
Mackerel, 361
shark, 340, 346
Macadamia (*see* Queensland nut)
MacCaughey, Prof. Vaughan (Botanist), 12, 152
Photographs by, 14
Machinery, Plantation, 274
Madagascar cowry [Leho puupuu], 470, 459
periwinkle, 250
Madreporite explained, 487
Maggot (405). The larva of a fly, but often applied to other worm-like creatures.
Maggots, 405, 419
Mahihi, 344, 354
Mahimahi (Common dolphin), 362
Mahiole. A war cap: a helmet (*see* plate 6. fig. 2).
Mahiole, 44
Mahogany, American, 211
Hawaiian, 211
Mahukona violet, 199
Makika, 388
Maia (Banana), 193, 257
(Chinese banana), 258
Maiapilo, 192, 199
Maiden-hair fern, 223. 419
Maieli, 230
Maii'i, 349
Maika, game of (*see* Ulu and maika)
Maile, 214, 216, 221
lei, 78, 216
lei, How made, 216
Use of, 71
Mairi=Maile
Major agricultural industries (raising sugar-cane), 274
Makaloa mat, 57
mats, how ornamented, 73
Makapuu Point, 109, 131
Makaweli cañon, 107
Makaweli valley, 107
Makiawa (Hawaiian herring), 350, 349, 358
Makiki valley, 117
Making fire, 40
of lauhala mats, 72
of salt, 73
stone adzes, 75
tapa, 76
Makua, 358
station, Barking sands at, 122
Malabar, 221, 249
Malay archipelago, 210, 249
peninsula, 304
Male children, How regarded, 46
Malo. A strip of tapa cloth girded about the loins of men; in former times the malo was the only dress worn by men when at work (*see* plate 5, fig. 1).
Malo, David (Native Hawaiian Antiquarian), 329
Malo ,Feather, 57
Tapa, 44
The, 38
of Umi, 44
Malolo (Flying fish), 366, 349, 355
Malpighia (*see* Barbados cherry)
Mamake=Mamaki
Mamake, 212, 217
Insects on, 411
Mamamo, 349
Mamani, 226
Use of wood of, 226
Mamanu=Mamano
Mamero (*see* Papaya)
Mammalia (295). The highest group of animals containing those forms that suckle their young.
Mammea (*see* Mammee apple)
Mammee apple (*Mammea Americana* Linn.) or St. Domingo apricot is well known in Hawaii, having doubtless been introduced from the West Indies where it is a native. The fruits are 3 to 6 inches in diameter, round, russet-colored or brown, with a yellow juicy pulp which may be eaten raw without flavoring—as the taste does not have to be acquired. Its nearest ally in Hawaii is the *Garcinia*. The tree, 20 to 40 feet high, has rigid leathery leaves.
Mamo, 332
Black, 332, 333, 335
feathers, use of, 75
Oahu, 335
Mana flats, 103
Sands at, 108
Mandarin orange (*Citrus nobilis* Lour.) is sometimes called the kid-glove orange, owing to the ease with which the ruddy, orange-yellow, loose, baggy rind may be removed. The fruits, small, slightly flattened and rough, are seldom more than two inches in diameter. The dense, low, thornless tree is a favorite with the Chinese.
Man-eater shark [Niuhu], 344, 345
Maneo (*see* Papaya)
Mango, 258, 241
Blight on the, 242
Fruit of, 241
Fruiting season of, 241
Fungus disease of, 242
Propagation of, 242
Species of, 242
-thrip, 428
Varieties of, 242
weevel, 395

Mangosteen (*Garcinia* spp.). There are about forty species known from tropical Asia and Africa; two or more occur, rarely, in Honolulu gardens. The dried juice of various species forms the yellow resinous pigment and purgative drug known as gamboge. All the known species have a yellow juice, opposite coriaceous leaves and a fleshy fruit with a thick rind.

Mangosteen, **246**, 269

Manienie (Introduced), uses of, 208, 286
Native, 208

Manila hemp, 280

Manini mango is a small variety introduced by Don Marin, perhaps one hundred years ago. It is said to be the first mango introduced into Hawaii.

Manini (Fish), 349, 372

Mano, a shark. There are many species of sharks, etc., which Hawaiians call by the general name mano. They were all tabu to women to be eaten only under penalty of death.

Mano (Hawaiian cub-shark), **340**, 349
kihikihi (Hammer-head shark), **340**, 346

Manoa valley, General view of, 270
Head of, **206**, 270

Man-o'-war [Iwa], **310**, 312, 314
Gular pouch of, **310**
Nesting habits of, 317
birds on the nest, **36**

Man-of-war, Portuguese, **490**

Mantis, Praying, 429
-shrimp, 468

Mantle [Mollusca] (457). An outgrowth of the dorsal body wall.

Manufacture of poi, 66
of salt, 129
of tapa, 69
of (*see* object in question)

Many celled animals, 499

Mao. A kind of shrub (*Abutilon incanum* Don.) used in dying tapa. The plant is common in low rocky districts. The name is also given to the wild cotton.

Mao (Cotton), 203, 281

Mapele. Name of a tree (*Cyrtandra* spp.) formerly much used in building a heiau in the worship of the god Lono.

Mapulehu valley, 135
Heiau in, **140**

Map of Ford's Island, **110**
Haleakala, **134**
Hawaii, **148**
Kauai, **104**
Keanakakoi (showing), **148**
Kilauea, **148**
Kilauea-iki, **148**
Lanai, **134**
lava flows (recent) on Hawaii, **148**
Leeward chain, **88**
Maui, **134**
Molokai, **134**
the Pacific Islands, **100**
Pacific Ocean, **100**
Pearl Harbor, **110**
Pearl Lochs, **110**
South Seas, **100**

Map showing Kupikipikio, **118**
Topographic, of Hawaii, **148**
Topographic of Kauai, **104**
Topographic of Maui, **134**
Topographic of Oahu, **110**

Margin shells, 452

Marin, Don Francisco de Paula (Early Horticulturist). Arrived in Hawaii 1791, died 1837.

Marine animals, Miscellaneous, **490**
bivalves, Common, **456**

Marine gardens. It was not uncommon in old Hawaii for the natives to have marine gardens, reserved for the growth of certain favorite species of limu. Choice species were occasionally transplanted from one locality to another by them. The care of these gardens as well as the gathering of limu was the work of Hawaiian women and children. Limu was the third most important article of diet in former times.

Marine plants and plant-like animals, **498**
plants, Common at Waikiki, **492**
worm, **490**

Marker at Kealakekua Bay (old copper), **84**

Market-fish, Choice, **362**
Fish in the, 348

Marketing, Suggestions on, 348

Markets, Hawaiian, 74

Maro Reef, **88**, 97

Marquesas Islands, 189

Marriage, 42
among persons of rank, 45
Ceremony of, 42
how solemnized, 45
-tie among Hawaiians, 45

Marsh, Birds of the, 320

Martain, Mr. 279

Marvel of Peru, 254

Masks, Gourd, **48**

Mat, **57**
making, Method of, **84**, 72

Mats, 59
Lauhala, 72
made by women, 73
Makaloa, 72
Niihau, **57**, 72
uses of, 72
used as sails, **48**, 72

Materials for tools, 74

Maternal relation, The loose, 45

Ma'u. The name of a fern (*Sadleria pallida* Hook. & Arn.) with a trunk 2-3 feet high, very common about Kilauea. It was eaten in time of scarcity and is the species said by some authorities to be referred to in the name of the crater pit Halema'uma'u.

Maua. A tree (*Xylosma Hawaiiense* Seem.) found in the forests of Kauai and Oahu where it is conspicuous by reason of the reddish color of the young leaves. On Maui and Hawaii, etc., a second species (*X. Hillebrandii* Waw.) occurs known by the same native name.

Maui, Age of, 237
amakihi, **332**
Area of, 237
a volcanic doublet, 237
beetle, 394
blight or Lantana scale, **384**, 385
Cañons on, 138

Coastal plain of, 138
Distances on (*see* Overland Distances)
Districts on, 134
Elevations on, indicated, 134
half-bill, 334
Harbors and landings on, 134
Iao valley on, 134
Island of, 132
Isthmus of, 134, 139
Kaupo gap, 134
Koolau gap, 134
Landings and harbors on, 134
Last eruption on, 147
Legend of, and the alae, 326
Map of, 134
-Molokai channels, 134
-Molokai-Lanai-Kaahoolawe group shown, 134
Outline of, 138
parrot-bill, 330
Position of, 100, 134
Principal lateral craters on, indicated, 134
Principal towns and villages on, 134
Relief map of, 134
Roads on, 134
Sand dunes on, 139
Scenery on Haleakala, 145
Secondary craters on, 134
Stages in geologic development of, 290
The 'Valley Isle,' 237
Topographic map of, 134

Mauna. A mountain; the inland region of an island.

Mauna Kea, 144, 149, 151
Algæ on, 152
Ascent of, 151
Small cones on, 151
Snow on, 154
Summit of, 154, 152
Summit of (near view), 154
Position of indicated, 148

Mauna Loa, 144, 151, 155
Ascent of, 155
Building of, 164
Dates of eruptions of, 183-188
Dewey crater on, 160, 161
Eruption of 1852, Coan's account of, 157
Eruption of 1914, 163
flow of 1907, 163
Flows on, 151
History of eruptions of, 155, 183-188
Lava discharged,1907, 163
Mokuaweoweo, 186
1905 eruption on, 162
Number of eruptions of, 155
on Molokai, 133
second largest active volcano, 155

Maxillary [fish] (369). The jaw bone.

May beetle, 417

Mayer, Dr. A. G. (Zoölogist), 483

'May-pops' (*Passiflora foetida* Linn.) have long been cultivated as a garden and veranda vine on account of their passion-flower blossoms which are followed by bright red, nearly globular fruits, nearly an inch in diameter. Children amuse themselves by popping the green and red seed pods. The fine green leaves are three-pointed.

Meadow grasshopper, 429

Meal worm, 405

Mealy-bug(s), 391, 427
-bug ladybird, 394
-bug on citrus trees, 265

Meandering River (Hanalei), Example of, 106

Measure shell, 470

Measuring worms (Loopers), 397

Me'e me'e (Half-beak), 350

Medicine, Hau used as, 201
Hawaiian, and botany, 79
of the Hawaiians, 79
practiced by women, 46

Mediterranean, 346, 360, 367
fruit fly, 386

Medusa explained, 480

Meek, Capt. John, 300

Melania, 436

Mele, Instruments to accompany, 83

Meles, 41
Type of composition of, 42

Melting point of lava (*see* Fusability of)

Melon-fly, 387, 419

Melon, Musk, 269
Tree (*see* Papaya)
Water, 269
Zapote (*see* Papaya)

Me'me'e, 358

Menehunes, Work of, 359
(*see* Fairy tales)

Menzie, Archibald, 153

Mesh gauge, 75

Mesquit, 242

Metallic wood-borer beetle, 417

Metamorphosis (403). The alternations, or transformation which an insect, or more generally, an animal undergoes in its development.

Meter. The unit of length of the French meterical system is the meter (abbreviation m.) which equals 39.370432 inches. The centimeter is the hundredth part of a meter (0.3937 inch); hence one inch equals very nearly 2.54 centimeters. The millimeter (mm.) is the thousandth part of a meter and equals very nearly 1-25 of an inch. One inch equals 25.4 mm. The metric system is much used by the scientific men of all countries as an international unit of measure.

Method of aquatic photography, 356
of gathering wauke, 59
of making calabashes, 59

Methods of warfare, 47

Mexican creeper or Mountain rose, 250, 248

Mexican poppy [Puakala], 198

Mexico, 242, 243, 249, 269, 284, 300, 388

Meyrick, E. (Entomologist), 420

Mice, 293
hunted as royal sport, 292

Microlepidoptera, 422

Middle-aged Hawaiian, 68

Middle forest zone, Plants of, 220, 222
Scene in, 200
Character of, 226

Mid-rib (210). The middle or main rib of a leaf.
Midway Island, **88, 90,** 94
Bird poachers on, 94
Bird poachers hut at, 90
Cable station on, **90**
Discovery of, 94
Introduced birds on, 320
Position of, 94
Sand grass on, **90**
Views across lagoon at, **90**
Views on, **90**
Vegetation on, **90**
Migration, Remarkable record of bird, 322
Migratory. Said of a species that makes regular or periodic visits to the islands from other lands.
Military organization, Ancient Hawaiian, 51
reservations at Pearl Harbor, **110**
reservations on, **110**
strategy, Hawaiian, 51
Milk, Cocoanut (juice), 235, 236
Milk-fish [Awa], **350,** 354, 363
Milkweed butterfly, 421
Miller-bird and nest, **316**
Laysan, 314, 319
Milling sugar-cane, Process of, **274**
Millimeter (*see* Meter)
Millipede, **398**
Millipeds, 408
Characteristic odor of, 408
Milo, 201, 203
in the native temples, 203
Uses of, 201, 203
Milu. The god of the under world. His abode was that of the deepest realm of misery, where those who were consigned to his care must live on lizards and butterflies.
Mimosa seed, Uses of, 207
Mina (*see* Mynah)
Mineral dyes used, 69
Minnows, 378
Minor agricultural, industries (*see also* industry in question)
industries, Cattle raising, **282**
Fishing, **344**
Rice growing, **270**
Mint, **198**
Minute land shells, 439
Miocene, 117
Mirror, Hawaiian, 62
Miscellaneous cultivated plants, **240**
fishing scenes, **344**
marine animals, **490**
views in Honolulu gardens, **246**
views on Hawaii, **150**
views (Hilo Bay), **352**
views on Kauai, **102**
views on Laysan, **92**
views on Leeward Chain, **96**
views on Molokai, **136, 142, 218**
views on Oahu, **270**
Misery, Abode of, 50
Mistletoe, Hawaiian, **214,** 205, 225
Mite(s), 400, 409
Orange, 265
Mitre shell, **470,** 451
Moa (Chicken), 308
Moa (Cotton plant), (*error see* Mao)
Moa (Trunk fish), **374,** 375
Moano, 373
Moanui valley, 135
Moaula falls, 133
Middle falls of, **136**
Upper falls of, **140**
Moepuu sacrifice [Human] (*see* Sacrifice)
Model of a canoe, **57**
Modern music, Hawaiian, 42
Moho (Hawaiian rail), **327,** 333
Moi (Fish), 349
(King), 55
Moiliili, 121
Moist woods, Ferns in (Hawaii), **190**
Mokihana, 221
Use of, 71, 221
Mokomoko (Boxing), which *see*
Mokuaweoweo, 155
History of, 155-163
Lava pool in, **186**
Night view of, **186**
on Mauna Loa, **186**
Vapors from, **186**
Mole cricket, African, 388, 430
Mollusca defined, 441
Types of, 441
Molluscoidea, 483
Mollusks, Air-breathing, 434
Living examples of primitive, 467
Native methods of cooking, 443
Molokai, Anchorage on, **134**
a volcanic doublet, 133
Bog flora on, **218**
Cloud cap over Kamalo, **142**
deer, 296
distance from Oahu, 132
Distances on (*see* Overland Distances)
Dunes on, **142**
Elevations on, indicated, **134**
Examples of talus debris on, **136**
Fossil root-casts on, **140**
Great heiau on, **140**
Hipuapua falls on, **140**
Island of, 132
Lanai, Kahoolawe, stages in geologic development of, **290**
-Lanai-Maui-Kahoolawe, Group, **134**
Landings on, **134**
mamo, 335
Map of, **134**
Miscellaneous views on, **142, 136, 218**
Mountain of Kamalo, **142**
Northwest coast of, **142,** 133
o-o, **330**
Position of, **100**
Principal villages on, **134**
reef, 135
reef, Gathering coral on, **142**
Scenery on, **136, 140**
Trail on, **218**
Water falls on, **140**
Monarch butterfly, 421
Money cowry, **470,** 458

Mongoose, 296, 308, 311, 328, 335, 339
Monkey-pod, 242
Size of, 242
Monstera, 246, 249
Curious fruit of, 249
Monterey cypress, 237
Montipora, 477
Monument, Capt. Cook's,84
erected by British govt., 84
in front of the Judiciary bldg., 44
Moo. A general name for all kinds of lizards; hence Mookaala a species common about rocks in dry regions: Mookaula a species occurring about dwellings, etc.
Moo (Lizards), 297
Mookaala (*see* Moo)
Mookaula (*see* Moo)
Mookini, Heiau of, 343
Moomumi, Camp at, 136
Cave dwelling at, 140
Dune erosion at, 142
General view of, 142
Moon-flower, Hawaiian, 202
-shell, 470, 461
Moorish idol [Kihikihi], 370, 361
Moray [Puhi], 350, 361
Morays (Eel-like fish), 350
Morning-glory, Beach, 192, 218
Five-fingered [Kooli ai], 192
Island, 197
leaf-miner, 423
Medical use, by natives, 197
Moon-flower, 202
Sea, 197
Morrison, D., 320
Mortars, 68, 70, 63
Moses, Ernest, Photographs by, 14
Moss animals, 480
"Moss" stone, 129
Mosses. In 1877 D. D. Baldwin published a list of 92 species of Hawaiian mosses. Other investigators have added species since bringing the total up to more than one hundred species.
Mosquito fish, 376, 378, 440
Mosquitoes, 387, 419
Moth, Clothes, 405
Hau, 397
Humming-bird, 398, 399
-like flies, 419
Sphinx, 398
Moths, 421
Leaf-rolling, 395
Mottled periwinkle [Kolealea], 470
Mountain apple, 28, 216, 256
apple trees, Birds frequent, 257
bog flora, 229
forests, Birds of the, 330, 334, 328
forest, Plants of the, 214
house, Old, on Haleakala, 145
ranges on Oahu, 110
ridges, Vegetation of, 218
rose, 248
scenery on Oahu, 130
scenery on Kauai, 102
scenery of Haleakala, 145
stream, Typical view along, 200
trail, 218
vegetation, Example of on Oahu, 125
Mountains: ON OAHU—Kaala (Waianae Range) 4030 ft., Palikea (Waianae Range) 3111 ft., Konahuanui 3105 ft., Lanihuli 2775 ft., Tantalus (Puu Ohia) 2013 ft., Olymphus (Awawaloa) 2447 ft., Round Top (Ualakaa) 1049 ft., Punchbowl (Puowaena) 498 ft., Diamond Head (Leahi) 761 ft. ON HAWAII—Mauna Kea 13,825 ft., Mauna Loa 13,675 ft., Hualalai 8269 ft., Kohala Mts. 5489 ft., Kilauea 4000 ft. ON MAUI—Haleakala 10,032 ft., Puu Kukui 5788 ft., Eke 4500 ft. ON KAUAI—Waialeale 5250 ft., Hoary Head (Haupu) 2030 ft., Kilohana Crater 1100 ft. ON MOLOKAI—Kamakou 4958 ft., Mauna Loa 1382 ft., Olokui 4600 ft. ON LANAI—Highest Point 3400 ft. ON KAHOOLAWE—Highest Point 1472 ft. ON MOLOKINI—Highest Point 160 ft. ON NIIHAU—Highest Point 1300 ft.
Mountains, Koolau, 211
Plants from the, 218
Waianae, 211
Mourning customs were various. Wailing was always indulged in. Some knocked out one or more of their front teeth; others cut their hair in odd ways; some tattooed their tongues; others burned their bodies in different places. Clothing, as well as moral restraint, was often discarded; houses were burned and general anarchy was liable to prevail.
Mourning, Shells as emblems of, 465
Mouse, 293
Mu (Porgie), 366, 349, 367
Mud-daubers, 404, 413
flow of 1868, 159
Muir, Dr. Fredrick (Entomologist), 383
Mulberry, 397
Black, 267
food for, 267
Paper, 217
shell, 470, 449
White, 267
Mulberries, 266
Mullet [Amaama], 362, 359
Fish destructive to, 353
ponds, Area of, 360
ponds, Old, 359
pond, 270, 359
Snake-head, 377
substitute for, 364
Value of, 360
Mumu (Goat-fish), 366, 373
Manienie, when introduced, 286
Murder was not uncommon in ancient Hawaii, the object usually being theft. Professional robbers lurked along the highways. Many of them were expert in their vocation, entangling their victim with a rope and leaping upon him so as to break his bones. Murderers when apprehended were usually stoned to death.
Murex, 449
Muscular young Hawaiian, 44
Mushroom coral, 488, 477, 479
Music, Modern, 42
Musical instruments, 82
Musk-melon, 269
Mussel, Common, 443
Hawaiian edible, 456
Mussels, 443
Goose, 473

Mutilations (*see* Mourning customs)
'Mutton' birds, 312
Muumai, 115
Mynah (Mina), 245, 306, 395
and the native birds, 306
feed on, 232, 268
Food habits of the, 306
Introduction of the, 306
Nest of eggs of the, 306
Myoporum (*see* Aaka)
Mytilus, 443
shells, Cluster of, **478**

N

Naenae, **220**, 227
Naenae (Surgeon fish), **370**, 372
Nahawele (Hawaiian edible mussel), 456, 443
Naieo (*error see* Naio)
Naio, 222, 226
Nakuina, Mrs. Emma Metcalf (Hawaiian Scholar and Antiquarian), 12
Names (*see* Nomenclature), 318

Nana uli (diviners) or soothsayers were a class supposed to be able to predict future events, as changes in the weather, the death of important persons, wars and the like from certain events, as the appearance of the sky, arrival of certain fish, tidal waves, etc.

Napaka (*error see* Naupaka)
Napali cliffs, 107

Nape (368). The upper or back part of the neck, usually writen 'the nape of the neck.'

Napkins, Hawaiian, 62
Napoopoo, 182

Narcotic (207). Generally producing sleep or stupor, though variously applied.

Narwhale, 301
Nassa, 451
Nasturtium, 208
Naticas, 461
National game, Boxing the, 83
Native amphipods, 409
and introduced fruits, **258**, 264
ant, 413
bat, 295
birds (*see* Chapters XXIII, XXIV, XXV)
centipeds, 407
cotton, 199, 203, 281
cutworm, 396
dogs, 295
fibre plants, 217
fish baskets and nets, 341
flora, **192**
fruits, 255
ginger [Awapuhi], **202**
grasses, 286
houses, how used, 39
in characteristic European dress, **44**
insects, 410
milipeds, 408
oven, how made, 66
palms, 236
plants, **192**, 191
plants, Curious, **206**
plants, Economic study of, 283
poultice, 197
rat, 291
Native (*see also* Hawaiian), 429
slug, 439
strawberry, 227
tobacco, 284
white ant, 425
woods, Number of species of, 226
Natural arch, Onomea, **150**
bridge at Makaha, **222**
bridge, Haleakala, 146
bridge on Oahu, **122**,
enemies, Insects controlled by, 381
enemies of lantana, **384**
graft shown, **218**
habitat of birds' nest fern, **190**
habitat of ieie vines, **190**, **200**
history of the Hawaiian people, 25-87

Naturalist (335). Usually one who is devoted to the study of the natural sciences.

Nature's school by the sea, 429
Na ukewae (Laysan albatross), **310**
Naupaka, **202**, **220**, 195, 222
Curious flowers of the, 197
Legend of the, flower, 197

Nauplius (373). An early stage in the development of the crab-like animals in which the larva has six legs and a median eye.

Naval battles, 51
Navigation of ancient Hawaiians, 30
Nawiliwili Bay, 105
Distance from (*see* Overland Distances)
Near view of Halemaumau, **166**
Neck of Maui, 139
an isthmus,**134**
Necker Island, **88**, **98**, 97
Discovery of, 97
Necklaces, 77
of ivory, 79
Seeds for, 204
"Needle," The in Iao valley, 138
Needle-fish [Ahaaha], **350**, 363
Sein, 75
Needles, Spanish, **196**
Nehe, 199
Nehu (Anchovie), **350**, 349, 351
Nemertinea, 497
Nene (Hawaiian goose), **310**, 323
Nerita, 465
Neritina, 465

Nerves [Bot] (213). The name applied to the ribs or veins of a leaf when simple or parallel.

Nerve-winged insects, 423
Nesting habits of the Man-o'-war bird, 317 (*see* species in question)
Nestlings (*see* species in question)
Nests, Bird (*see* species in question)
Spider, 410
Wasp, 404
Net, Dip (large), 344
fishing, **344**
Long sea, **344**, **352**
Sea, Landing a, **344**
Throw, **344**

Nets [Koko], **68**
Bag, 341
Dip, 341
Fish, 73
Gill, 339
of olona, 73
Opelu, 341
Nettle, Sea, 480
Newa, **44**
Newell's shearwater, 309
New industries (*see* Industries), 281
Zealand, 229, 281, 307
Night birds, 309
blooming Cereus, **246**, 254
fishing, 242
heron, Black-crowned, **310**, 325
-mare, How interpreted, 49
mosquito, 387
view of Mokuaweoweo, **186**

Niho. A tooth, especially a whale's tooth: hence Nihopalaoa, an ivory ornament, worn pendent from the neck, made from the ivory of the whale or walrus. Originally this ornament was worn only by high chiefs (*see* plate 10, fig. 1).

Nihoa (Bird Island), **88**, **96**, 98
Position of, 98
Visited by, 98
Niihau, Description of, 101
Island, **88**
mats [makaloa], **57**, 72
mats, how ornamented, 731
Position of, **100**, 101
shell, **470**, 101, 453
Nitidulid beetles, 388, 417
Nitrogen in soil, 105

Niu. The name of the cocoanut tree. Under the tabu system females were forbidden to eat the nuts under penalty of death.

Niu (*see also* cocoanut), 201, 236
uses of ,236
Noah's ark shell (Ark shell), **456**
Nobility a powerful class, 54
Nectuids, 396

Nocturnal (309). Active at night, appearing at night.

Noddy tern, **310**, 311, 318
Nohu (Scorpion fish), **374**, 168
Nohu, **92**, 199, 368
Nohuanu, 229

Nomenclature. The systematic naming of things. Scientific knowledge is based primarily on the classification of facts. Classification in general consists in observing objects and placing those which are alike in one or more characters in the same group under a common name. As the study of living objects has advanced, and the number of species been increased through research, the detail of providing a separate and definite name for each living thing has become an enormous task. This labor is largely performed by specialists, who working as botanists, zoölogists, entomologists and the like, are guided in the naming of objects in their respective fields, by certain more or less definite rules known as the rules, or canons of nomenclature. By these rules scientific or technical names are applied which are intended to serve the double purpose of providing a definite name for the animal or plant, and at the same time, one which will indicate its relation to other similar groups and to still other groups from which it differs more or less in important characters. Natural classification attemps to indicate the relation of groups to other groups of varying degrees of similarity. In this scheme of classification and nomenclature a number of terms are quite generally applied, in the biological sciences, with the general meaning of which every person should be acquainted. The classification of the domestic cat is a familiar example and one that serves well to indicate the important points in the whole scheme of classification and nomenclature in force among both botanists and zoölogists.

The many varieties or breeds of domestic cats indicates the variation liable to occur within a given species. The lion and the tiger differ more widely in their characters and for that reason are given different specific names, but they, together with the common cat (as well as numerous other species), are all grouped together as species belonging to one GENUS (Felis). The genus Felis and other genera, in which are placed less common catlike animals, are grouped together in a larger group—the FAMILY (Felidæ). This important group, together with the members of the dog family form a still larger group—the ORDER (Carnivora). These families, as an order, are included with other orders to form a CLASS and so on, as indicated in the following diagram:

Kingdom—Animalia.
Phylum—Chordata.
Class Mammalia.
Order—Carnivora.
Family—Felidæ.
Genus—Felis.
Species—*Felis domestica*.

The name of the animal is generally understood to be its generic name followed by its specific name. To this, under varying rules, is usually added as authority for the name, the family name of the person first publishing an accurate description of the animal or plant. Variety names are added under the same general rule; the names of the sub-species or variety following that of the species as *Asio accipitrinus sandricensis* (Blox.). The name indicating that the Hawaiian owl is a variety of the short eared owl of America and that it was first described by Bloxham. The name of the authority being enclosed in parenthesis (Bloxham) indicates, to the student of nomenclature, that the species has been changed from the original genus to which Bloxham referred it in the original description.

Non-calcarious sponges, 500
Noni, 201, 205
Distribution of, 205
uses of, 205
Norfolk Island pine, 237
North America, 191, 204, 226, 346
coast of Molokai, 133
-east coast of Hawaii, **154**
Pacific currents, 191, 248
Norway, 291
rat, 291
Nose flute, 82
how played, 82
player, **40**, **76**
of Hawaiians (characteristic), 38
Notes, comments, observations, where found, 10
Notochord, 484
Noxious animals, 35
Nuihi, 345

Number of eruptions of Mauna Loa, 155
of illustrations, 7
of species of palms, 232
of species of (*see* genus, family, class, or order in question)
Nunu (Trumpet-fish), **350**, 375
Nut(s), 285
Almond,248
Betel, 236
Candle, 239
Cocoanut palm, 236
grass, 287
grass [Kaluha], **196**
Kukui, how used, 239
Lauhala, 204
Nutting, Dr. C. C. (Zoölogist), 479, 480
Nuuanu Pali, **125**
valley, 109
valley, View in, 112
Nuumele (Wild ipecac), **212**
Nymph, Dragon-fly, **436**

O

Oahu, Age of, 117
A laboratory in vulcanology, 109
a volcanic doublet, 113
Boys on, **110**
Breaks at Kaena, **122**
Capes and points on, **110**
Cities on, **110**
College=PUNAHOU ACADEMY, **246**
Common corals from, **486**
Common ferns on, **228**
Common Lobelias on, **206**
Coral reefs on, **110**
Dimensions of, 109
Depression of, 121
Distances on, **110**
Distances on (*see* Overland Distances)
Districts on, **110**
Economic products (geologic), 127
elepaio, **337**
Erosion on shown (Maunawili), **130**
Estimated age of, 124
Evidence of subsidence of, 220
Examples of sea cliff on, **122**
Field and roadside plants on, **198**
Field boulders on, **130**
Fresh water fauna of, **436**
General view of Koko Head, **472**
Geologic history of, 219, 220, 221
Harbors on, **110**
Haunama Bay, **128**
Highest point on, 109
Highest points on (indicated), **110**
General view on shore-line, **270**
Geologic objects of interest on, 129
Island, **88**, 109
Islands visible from, 132
Kahana Bay, **128**
Kahana valley (drowned valley), **128**
"Knife edge" ridges on, **130**
mamo, 335
Manoa valley on, **270**
Military reservations on, **110**
Miscellaneous views on, **112, 116, 122, 125, 128, 130, 270**
Mountain scenery on, **130**
Mountain ranges on, **110**
Natural bridge on, **122**
Plantation scenes on, **274**
Plants of the mountains on, **214**
Plants of Lower forest zone on, **202**
Plants of Middle forest zone on, **220**
Papa holau slides on, 86
Position of, **100, 110**
Pond life on, **436**
Rabbit Island, **128**
railway, Exposures on, 132
railway on, **110**
Re-elevation of, 121
Reef on, at low tide, **472**
Rivers on, **110**
Rivers on, **100**
Roads on, **110**
Rocky shore-line, **130**
sand dunes on, **122**
Scenery on, **270**
Secondary craters on ,**110**
Shore-line of, 109
Small tuff and basaltic craters, 115
Spirit leaps on, 50
Stages in the geologic development of, **290**
Streams on, **110**
Surf at Waimea, **128**
Topographic may of, **110**
Towns and villages on (principal), **110**
Valleys on, **110**
Water falls on [Waipuhia=Blown water], **112**
Wind blown sand on, **122**
Oak, Australian, 248
Silk, 248
Objects of geologic interest on Oahu, 129
of recent manufacture, Hawaiian, **60**
of worship, 49
tabued, 47
Observations, notes, comments, where found, 10
Obsidian, commonly called volcanic glass, is a volcanic rock, in various conditions closely resembling bottle-glass in appearance and texture. It belongs to the trachyte group of rocks, but is of rare occurrence in the islands in the typical form. Specimens variously colored, as black, brown, greenish and bluish-white have been found by the author on various islands of the group. Pele's hair and pumice (which *see*) are forms of this rock.
Occasional visitor (Birds). Said of a species that occurs in small numbers at irregular intervals.
Occupations of Hawaiians, 63
Ocean boneto [Aku], **344, 366**, 361
-borne plants, 195
Ocean Distances: HONOLULU to San Francisco 2100 miles; San Diego, 2260 miles; Portland, 2360 miles; Panama, 4720 miles; Tahiti, 2440 miles; Samoa, 2290 miles; Fiji, 2700 miles; Auckland, 3810 miles; Sydney, 4410 miles; Hongkong, 4920 miles; Yokohama, 3400 miles; Guam, 3300 miles; Manila via N. E. Cape, 4890 miles; Victoria, B. C., 2460 miles; Midway Island, 1200 miles.

Island, 88, 94
Islands, Birds of, 308
Island, Position of, 94
Island, View on, 90
Ocherous ladybird, 394
Octopus or Devil fish [Hee], 442, 441
at the Aquarium, 442
Odd fishes, 374
Odor of Hawaiian birds, Peculiar, 331
of sandalwood, 221
Oedemerids, 418
Oeoe (Hawaiian stormy petrel), 323
Offerings to stop the 1801 flow, 152
in time of war, 51
Peace, 53
Oha wai, 212, 214
uses of, 226
Ohe, 224, 203, 209

Ohekapala (*Ohe*=bamboo and *kapala*=to print). A piece of bamboo carved for the purpose of printing tapa (*see* tapa making).

Ohelo berries, 258, 227, 256
papa, 255
Tall, 220
Ohia, 190, 220, 215, 216, 226, 228

Ohia ai. A useful fruit tree (*Jambosa Malaccensis*) usually known as *Eugenia malaccensis* Linn., bearing the mountain apple. The wood was also used in house building, etc.

Ohia ai, 216, 256
ha, 220
lehua, 220, 209, 215, 216
wai (*error see* Oha wai)
uses of, 215
Ohua, 349
Ohulenui (old Hawaiian), 60
Oi, 205
Oil, Cocoanut, uses of, 22, 236
Exile, 252
Illuminating, 62
Kukui nut, use of, 62
Palm, 237
Shark, 346
Whale, 302
Whale, yield of, 303
Oio (Bone-fish), 350, 349, 354

Okelehao. The name given to an intoxicating liquor formerly distilled by natives and foreigners from *ki* roots. Its manufacture in illicit stills continues in the back country sections.

Okolehau, 210
Okupukupu, 228
Old age among Hawaiians, 45
Hawaiians, 24, 60
Government Nursery, 238
'Stump leg' (plover), 322
-world limpets, 466
Olea (*see* Olive)
Oleander, 252
poisonous, 252
white scale, 391
Yellow, 252

Olena. The name of a plant (*Curcuma longa*) the root of which was used in dyeing yellow. It resembles the *awapuhi*, which *see*.

Olepe (Tellen shell), 456, 445
Olinda beetle, 394

Olive (*Olea Europa* Linn.), although seldom fruiting in Hawaii, the 'oil tree' is nevertheless well established, and is grown usually as an ornamental tree. The dull, whitish green, small, thick, lanceolate opposite leaves are characteristic of this low-growing tree. It has been cultivated from the earliest times in Syria and Palestine and in remote antiquity was distributed throughout the whole Mediterranean region. In recent times it has been successfully planted in America, Australia and elsewhere. The wild olive (*O. Oleaster*) was once sacred to Pallas and its leaves were used for victors' wreaths among the Greeks and Romans—hence 'the olive branch.' Many cultivated varieties of *O. satira* are recogniezd.

Olive shells, 452
Olivine (*see* Chrysolite)
sand, 129
Olohu stones, 83
Olokele cañon, 102, 106, 107
Olokui, 133
mountain, Sea end of, 136
Olomea, 40
Olona, 202, 67, 217
board [laau kahi olona], 64
cord, 64
cord, uses of, 75
fiber, How secured, 217
how cleaned, 299
how grown, 73
Method of preparing, 64
Nets of, 73
use of, 73, 77, 79, 81, 203
Olowalu valley, 138
Olympus trail, Ferns along, 206

Omaka. The foreskin in males removed in circumcision as formally practiced among the Hawaiian. Also the nipple of a female. The surgical instrument used in circumcision was usually a sharp splinter of bamboo. The operation was resorted to chiefly as a sanitary measure.

Omaka (Wrasse fish), 366, 349, 359
Omau (Hawaiian thrush), 334
Omilu (Cavalla), 362, 349
Ono, 349
Onomea, Arch at, 150
gulch, 176
Ornament of braided hair, 60

Oo. An instrument anciently and in a modified form still used by Hawaiians in cultivating the ground. It was made of hard wood as alahee, ulei, kauila, uhiuhi, etc., and was long and flattened at one end to form a digger.

O-o a-a, 337
O-o (Bird), 330, 333
Feathers of, use of, 77
Oo (Digger), 75
Oopu (Goby), 374, 349, 357
how captured, 357
Oopuhue, 349, 367
Oopukai (Cirrhitoid fish), 374, 349
Oopu kawa (Porcupine fish), 370, 365
Opae (Shrimp), 436
Opae (fig. 1), 482
baskets, 341
Opakapaka (Snapper), 362, 349, 364, 371
Opeapea, 295

Opeas, 439
Opelu. The opelu and aku were two kinds of fish that were sacred and tabu by turns for six months at a time. On January 13th each year a human sacrifice was offered together with the fish aku. The Kahoalii, a man personifying the god of that name, is said to have plucked out and ate the eye of each. By this ceremony the tabu was taken from the aku and the opelu in turn became tabu for six months.
Opelu, 349, 363, 364
nets, 341
palahu (Mackerel), **366**, 349
Operculate land shells, 438
Operculum defined, 443
False, 439
from Viviparus, **436**
in Turban shell, **460**
Opihi, 466
"Opium" tree [Opiuma], **198**
Opu. A protuberance with an enclosure as the belly, stomach, bladder, etc. The Hawaiians supposed the seat of thought, intelligence, etc., also the seat of moral power to reside in the small intestines; hence *opu* or *naau* was used by them for what we call the heart.
Opule (Wrasse fish), **366**, 349, 359
Oracle [Lananuu]. A tall framework of poles in the temples shaped like an obelisk. It was four to six feet square and hollow. In it the priest stood to get in direct communication with his god that he might learn the will of the god on important matters.
Oral and aboral view of sea-urchin, **496**
Orange, 263, 264
aphis, 265, 389
Chinese, 266
groves, Old, 135
Introduction of, 264
Large trees of, 265
mite, 265
-red birds [Akepa], 333
Russet, cause of, 265
Orca, 347
Order (*see* Nomenclature)
Oreomystis, Genus, 331
Organ pipe coral, 429
Oriental method of rice cultivation, 276
Origin of bird fauna, 338
Hawaiian plants, 193
the Hawaiian race, 26
the Polynesian race, 26
Ornamental palms, 236
Ornaments, 38
Feather, 75
Flowers as, 38
Human teeth as, **70**
Nut shells ,ivory, as, 38
Ornament shell, **470**
Ornithologist (329). One who is devoted to the study of birds.
Osculum explained, 499
Ostergaard, J. M., 447
Ou, 331
use of feathers of, 77
O-u, **337**
holowai, **337**
Outline of head of Maui (*see* map of), **134**
Outfit for reef collecting, **478**
Otaheite gooseberry (*Phyllanthus distichus*, Müll.) Although extensively cultivated in the tropics for its acid fruits, which are used for pickles, it is rare in Hawaiian gardens. This low growing tree with large pinnate leaves belongs to the very large tropical genus *Phyllanthus*, commonly represented in the islands by the variegated *Phyllanthus roseo-pictus*, much used as a hedge plant. It is a native of Java. The fleshy green fruits, an inch or more in diameter, occur in long clusters. A related species with finely pinnate leaves (*Phyllanthus emblica* Linn.) is rare in Hawaii. A single tree may be seen in the Mausoleum grounds in Nuuanu Valley. The round fruits, ¾ inch in diameter, are slightly flattened and six-striated.
Ovary [Bot] (260). The part of the pistil which contains the future seeds.
Ovate (203). Like the section of an egg with the broader end of the leaf next to the stem.
Overland Distances: ON OAHU—From Honolulu P. O. to Diamond Head 5.9 miles. Koko Head 11.8 m., Makapuu 14.8 m., Waimanalo (by the Pali) 12 m., Pali 6.6 m., Kaneohe 11.9 m., Waiahole 18.9 m., Kahana 26.4 m., Kahuku Mill 37.2 m., Waialua 28 m., Kahuku Ranch (via Waialua 39.4. *By Rail* from Honolulu Depot—To Puuloa 6.23 m., Aiea 9.37 m., Pearl City 11.76 m., Wahiawa Station 25.20 m., Ewa Plantation Mill 18.25 m., Waianae Station 33.30 m., Kaena Point 44.50 m., Waialua station 55.80 m., Kahuku Plantation 69.50 m., Punaluu 80.50 m. ON KAUAI—Nawiliwili: to Koloa 11.0 m., Hanapepe 20.0 m., Waiawa 31.5 m., Nuololo 44.8 m., Hanamaulu 3.3 m., Wailua River 7.7 m. Kealia 11.9 m., Kilauea 23.6 m, Hanalei 31.8 m., Wainiha 34.8 m. ON MAUI—from Kahului: to Spreckelsville 4.0 m., Paia P. O. 7.2 m., Haiku 11.0 m., Huelo 20.2 m., Nahiku Landing 49.9 m., Hana P. O., 55.6 m., Kipahulu Mill 66.2 m., Wailuku 3.8 m., Waikapu 5.9 m., Maalaea 10.3 m., Kihei 12 m., Makawao 11.6 m., Olinda 18.5 m., Haleakala (crater edge) 26.6 m Haleakala summit 28.6 m., Olowalu 19.9 m., Lahaina Court House 25.5 m., Waihee 7.3 m., Kahakulou 16.3 m., Napili 29.8 m. ON HAWAII—from Foreign Church (Kohala) to Hamakua boundary 4.5 m., Kukuihaele Mill 11.0 m., Mana 7.7 m., Honoipu 7.25 m., Mahukona 10.5 m., Mahukona to Court House 9.2 m., Kawaihae to Waimea Court House 11.8 m., Mana 19.5 m., Kohala Court House 15.0 m., Kealakekua to Kailua 12.0 m., Kiholo 27.6 m., Kawaihae 42.0 m., Honaunau 4.0 m., Hookena 7.7 m., Kahuku Ranch 36.5 m., Volcano to Halfway House 13 m., Pahala 23 m., Punaluu 27.6 m., Honuapo 32.6 m., Waiohinu 37.1 m., Kahuku Ranch 43.1 m. From Hilo Court House 13 m., Pahala 23 m., Punaluu 27.6 Road 9 m., Pahoa 20.0 m., Pohoiki 28 m., Kapoho 32.0 m., Furneaux's 13.2 m., Mountain View 16.8 m., Volcano House 31.0 m. ON MOLOKAI—From Kaunakakai: to Meyers, Kalae, 5.0 m., Kalaupapa 9.0 m., Kamalo 9.0 m., Pukoo 15.0 m., Halawa 25.0 m.
Oviparous fishes, Example of, 358
Ovipositer (429). An organ by which many insects place their eggs in places suited to their development.
Owalii, 227
"Owl" fish [Moa], 375
Owl, Hawaiian short-eared, 336
Owlet moths, 396
Owls, Sacred. In time of danger the appearance of an owl was regarded as a favorable omen. Kukauahi was the god of owls.
Ox bot-fly, 421
Oyster beds attacked by starfish, 489
culture, Attempts at, 445
Extinct, 444
Fossil, 115

Hawaiian, **456**
Pearl, **456**, 444
Rock, **456**, 446
Saddle, 444, 445
Oysters, 443, 473
California, 445
Eastern, 445
True, 444

P

Pa (shell), 444
kuikui, 372
(Pearl oyster), **456**
Pacific, 191, 216, 225, 236, 300, 301, 303, 312, 346
Coral reefs of the, 477
golden plover [Kolea], **303**, 321
Highest mountain in, 147
Islands, 203, 257, 320
Islands, Map of, **100**
Islanders (Polynesians), 25
Ocean ,95, 99, 111, 324
Ocean, Cross roads of, 99
Ocean, Map of, **100**
Sphynx of the, 115
Whaling in the, 303
Paddle [Hoi],Canoe, **70**, **80**
Paddy, 276

Pahee was a game in which short blunt darts of polished hard wood from two to four feet in length were thrown along the ground between two darts laid down at a certain distance.

Pahoehoe and a-a shown, **162**
Examples of in Kilauea, **184**
flows in Kilauea, **166**
flows on Mauna Loa, 155

Pahu. The pahu was originally a hollow cocoanut stem or other tree with a shark skin drawn over one end and used as a drum (*see* plate 11, fig. 1).

Pahu hula, **57**
Paiai, 66
Painted fish, 359
Painters' brush (a composite), **262**
Painui, **206**, **224**
Pakii, 349, 371
Pakuikui, 347

Palagonite. A volcanic rock closely allied to basalt having a somewhat vitrous structure; the craters of Diamond Head, Punchbowl, etc., are largely composed of this rock.

Palahola. A paste made from the fern amaumau (*Sadleria cyantheoides* Kaulf.) which was used as a gum in repairing tapa.

Palaoa, 79, 301
Palapalai, 221
Palaui=Palawi
Palawi, 349
Pali, Eruptive center beyond, 220
Height at the, 114
road (1214 feet), **125**
The, **125**, 114
The, a wind gap, **125**
The, View near, 112

Pallial line. The line or mark made by the mantle in certain Mollusca on the inner side of the shell.

Palmate (262). Said of a leaf when the leaf, or the divisions of the leaf, spreads from its stalk like the open hand.

Palm blossoms, Bees feeding on, 232
Blue, 237
Bottle, **240**, 237
Chinese, 237
Cocoanut, 233
Date, **234**, **238**, **246**, **264**, 236
Fan, **240**, 236
Japanese, 237
leaf, Danger from falling, 233
leaf-roller parasites, 396
leaves, how used, 235, 236
leaves, Scale on, **384**
lily, 210
mealy-bug, 391
oil, 237
Rhapis, **240**, 237
Royal, **246**, 232
Sago, 237
Sugar, 237
Sunday, 236
Travelers, **238**, 257
trees on Cocoanut Island, **150**
trees on the sea-shore, **150**
Washington, **246**, 237
"Weeping," 237
Wine, **246**, 237
Wine, fruit and flowers of, **246**
Palms, 232
as a domestic setting, 233
at Waikiki, 233
Cocoanut, age of, 233
Native, 236
Number of species of, 232
Ornamental, 236
The "prince of," 233
Palm thatch, 236
Palolo-Manoa trail, View on, **218**

Palolo. Sticky mud. A bluish-white clay of the islands.

Pamoho=Okupukupu
Pampanos, 364
Pampas grass, **238**
Pandanus, 204, 252
Aërial roots of, 252
baskets, **20**
distribution of, 204
Species of, 252
use of, 62, 81
Pan-Hawaiian Island, **290**

Panicles (227). A loose branching cluster of flowers.

Panini, 209
Pantheon, The Hawaiian, 49
Papa hee malu (surf board), **80**
holua, **57**, 86
holau slides on Oahu, 86

Papa, wife of Wakea. They were regarded as the founders of the Hawaiian race.

Papai lanai, 469
Papaia (*see* Papaya)

Papain is a ferment obtained from the half-ripe fruit of the papaya. It differs from pepsin in that its proteolytic action goes on in the neutral or alkaline solutions. It is also called papayin, papayotin, and carican.

Papala, 214
Papaua, 456, 443
Papaw, 262
Papaw (*see* Papaya)
Papaya. The common name for both the tree and fruit of *Carica Papaya* is derived from the Carab "ababai" which doubtless is a corruption of the American name papaya since the species is known to be of South American or West Indian origin. The papaya has so long been in cultivation in the tropics that it is known under at least a dozen common names, variously spelled, some of which are used interchangeably even by the same authors. Papaya seems preferable as the distinctive English name, although papaia is a common spelling. Other current English names are tree-melon, pawpaw (which *see*), papaw, melon zapote, lechoso, maneo, and mamero.
Papaya 264, 262
Property of the juice of, 263
Varieties of, 262
Paper mulberry [Wauke], 67, 69, 217
wasps, 404
Papiopio (Cavalla), 362, 349
Papipi. The prickly pear. Also called panini.
Para grass, 286
rubber, 283
Paralysis, transmitted by, 419
Parasitic Hymenoptera, 412
plant, Example of a, 204, 225
Parasites (381). An animal that lives in or on or at the expense or by the exertion of another species.
Parasites, Egg, 382
of the leaf-hopper, 382
Parents and children, Relation between, 45
Parrot-bill, Maui, 330
fish, 365
-fish, Common [Uhu], 370
-fish, Blue, 365
Parrots, 308
Parthenogenesis, 391
Parthenogenesis (390). In some animals in which fertilization normally occurs, the ova may develop in the absence of the male element; hence virgin reproduction.
Partridge, California, 308
tun [Puonionio], 460, 461
Party visiting 1905 flow, 162
Paspalum, 208
Passenger and mail landings (*see* Bays, etc.)
Passiflora (*see* May-pops, Water-lemon, etc.)
Passion flowers, 268
flower, Origin of name of, 268
fruit (Grandilla), 264
Paste (*see* Varnishes)
Pa'u, Feather, 57
hula, 82
Made of, 38
The, 38
Pa'u. The principal garment of a Hawaiian female in former times, consisting of a number of tapas, generally five, wound around the waist and reaching about to the knee (*see* plate 11, fig. 3).
Pauohiiaka, 192
Paupau (Cavalla), 362
Paupilipili, 196
Paving blocks, 215
Pawpaw (*see* Papaya)
Pea, 489, 491
Peace, How proclaimed, 53
offerings, 53
Peaches, 267
scale, 391
Pea-fowl, 308
Peahi, 228
Peanut, native of, 285
Peanuts, 285
Pear, Alligator, 261
Alligator=Avocado, 258, 261
Prickley, 269
Pears. Pears (*Pyrus communis*) occasionally fruit in the islands in the higher altitudes. They are of fairly rapid growth and produce a fruit of good quality. They thrive best at from 4000-5000 feet elevation.
Pear, Sapota, 266
Pearl and Hermes Reef, 88, 94
and Hermes Reef, Seal on, 96
City Peninsula, 110
City, Plan of, 110
Harbor, 109, 211
Harbor, Map of, 110
Harbor, Evidence of elevation of, 130
Harbor, Fortification of, 211
Harbor, Fossil shells at, 130
Harbor, Military reservation at, 110
Harbor, Shark fishing off, 344
Harbor, Soundings in, 110
Lochs, Map of, 110
Lochs (*see also* Pearl Harbor), 115, 132
oyster [Pa], 456, 444
shell, use of, 77
Pearls, 444
Peculiar. A species occurring only on the islands of the group (*see* endemic).
Pectoral fins (347). Situated on the side of the body, usually just behind the head.
Peduncle defined, 473
Peduncle (Mollusca), explained, 445
Peelua, 388
Pele, Coming of (legend), 89
Kapiolani breaks the spell of, 171
Ohelo offering to, 225
The journey to visit, 132
Pelekunu valley, 133
valley, Bog flora at, 218
Pele's hair (*see* Obsidian)
hair, 180
kitchen, 179
reception room, 179
reception room, Flashlight of, 170
reception room, Entrance to, 184
Pendent [Roots] (211). Hanging like the aërial roots of a banian.
Pendulum Peak, 143
Peninsula at Pearl City, 110
Pens, Fish, 341
Pepeiao kai ("Sea ear"), fig. 1, 492
Pepper, California, 240
grass, 287
tree, 245

Perch-like fishes, 369
Sea, **366**
Perennial (205). Living on from year to year, as distinguished from an annual.
Perfumes, Hawaiian, 221
Periwinkle(s), 441, 464
Madagascar, **250**
Mottled, **470**
Perkins, Dr. R. C. L. (Entomologist, Naturalist), 12, 295, 407, 414, 411, 422, 424, 440
Perna, 443
Persons tabued, 47
Peru, 254, 266, 284, 293
Marvel of, 254
Earthquake, 1868, 159
Pestles, **68**
Stone, **70**
Pests, Household, 405
Mongoose, 296
of the banana, 260
of citrus fruits, 265
Pineapple, 261
Petiolate (254). Said of a leaf when born on its own leaf-stalk.
Petos, 361
Petrel, Bonin, **310**
Bulwers, **310**
Dark-rumped [Uau], **310**
Hawaiian stormy, 323
Petrels, 309
Pheasant, Chinese, 307
Japanese, 307
Ring-neck, 307
shells, 466
Pheasants, 307
Hybrid, 308
Philippine Islands, 235, 280
Philodendron, **234**, 240, 249
Phosphate of lime, 95
Phosphoric acid in soils, 105
Photographs, Credit for, 12, 14
Phyllanthus, 252
(*see* Otaheite gooseberry)
Phylodendron (*error see* Philodendron)
Phylum (*see* Nomenclature). One of the large branches of the animal kingdom.
Physical characteristics of Hawaiian people, 37
Pia, 284
Picking coffee, **270**
Pickle-weed, **192**, 199
Pig [Puaa], dishes, 61
prepared for baking, **36**
Dish of baked, **70**
Pigs, 287
Food for, 67
Wild, Forest damaged by, 287
introduced, 295
(*see also* Hogs) introduced, 295
Wild, 295
Piiku. A drink made from the leaves, branches and fruit of the kukui tree and used for medicine.
Piipii (Stick-tight grass), **196**, 286
Pikopiko. The name of the ink or sepia in the squid. When emitted it clouds the water a murky brown, enabling the animal to escape.
Pilali. The gum of the kukui tree, but also a general term for a gum.
Pili, **192**, 59, 209, 286
Pilikai. The name of a stout woody climber (*Argyreia tiliæfolia* Wright) with pale purple flowers the seeds of which were used as a cathartic for children.
Pilikoa'a, 354
Pilikoa (Cirrhitoid fish), **374**, 354
Piling, Worms from, **490**
'Pillars' lava (Puna), **158**
Pill-bug, **398**, 408, 409
Pillow, Hawaiian, **57**, 62
Pilo, 227
Pilot-fish, 365
Pilot fish or Romero, **366**, 365
Pilsbry, Dr. Henry A. (Conchologist), 12, 121, 123, 124, 290, 434, 435, 473
Pinau (Dragon fly), **436**, 424
Pinch-bug (beetle), 417
Pineapple, **258**, 255, 261
disease of sugar-cane, 261
Flowers of, 261
mealy-bug, 391
Propagation of, 261
Seasons for, 261
Seeds of, 261
scale, **384**, 391
Size of, 261
Varieties of, 261
Pine, Ground, **214**
Screw, 252
"Pin-head" shells, 439
Pink shower, 244
sugar-cane mealy-bug, 389
cotton boll worm, 399
Pinnate [leaves] (244). When the small leaflets are arranged along the side of a common stem.
Pintail duck, 328
Pioeoe (Barnacles), 473
(Hawaiian oyster), **456**, 444
Pioi, 213
Pipe-fish, 365
Pipe, Hawaiian, 284
Pipi, 445
Pipipi, **436**, **442**, **444**, **470**, 79, 465
Pipul tree, 283
Pirate bird, 318
Pisa shells, 450
Pistil (216). The seed-bearing organ of a flower.
Pit crater, Keanakakoi, **186**
of Halemaumau, **166**
(*see* Halemaumau), **174**
scale, 391
Places (*see* Cities, etc.)
tabued, 47
Plague carried by fleas, 401
Carriers, Rats as, 292
Germ of, 292
how contracted, 292
organism, 401
Plain (Alluvial), Examples of, **106**
Plaiting lauhala mats, **84**
Planarians, 497
Plan map of Diamond Head, **118**
Plant and animal dyes, 69

Plantain, 259
Plantains, Cooking, 212, 260
Plantation, General view of (sugar), 278
laborers, 274
machinery, 274
rice, 270
scene, 274
Sisal, 270
Traction engine on a, 274
Trash fire on, 270
Plant controlled by its enemies, Example of a, 384
Juices use of (*see* Ki, Awapahi, Hau)
lice, 389, 425, 427
lice, Life history of, 391
life, Effect of agriculture on, 269
life of the high mountains, 210
life of the lowlands, 189
life of the sea-shore, 189
-like animals, 498
parasite (*see* Dodder, Mistletoe, etc.)
Umbrella, 234
Planting and harvesting sugar-cane, 278
seed cane, 278
Plants and animals brought as baggage, 27
as gods, 49
at Waikiki, 116
by the sea-shore [Lauhala], 194
Common roadside, 198
cultivated by the natives, 67
Economic study of native, 283
Endemic, 191
Fiber, 69
Field and roadside (common), 198
from the coral reef (Part one), 468
from the coral reef (Part two), 485
from the mountains and the shore, 218
from the rocky coast, 192
from the sea-shore, 192
from the shore to the forest, 201
from the summit of Konahuinui, 224
Hedge, 251
Introduced, 191, 205, 231
Introduction of, 283
Lantana, spread controlled by, 385
Marine, at Waikiki, 492
Native, 192
Native fiber, 217
Number of genera and species of, 191
of the lower forest and fields, 212
of the lower forest zone, 202
of the middle forest zone, 220
of the mountain forest, 214
peculiar to Hawaii, 193
Precinctive, 193
Rare exotic, 238
Second zone of, 201
transported by currents, 191
Plates engraved by Hawaiian Gazette Co., Ltd., Honolulu
Plates, List of, numerically arranged,
SECTION I—THE HAWAIIAN PEOPLE.
1. Typical old Hawaiians of today, 24
2. Hawaiian grass house with typical setting, 28
3. Hawaiian children, 32
4. Preparing Hawaiian food, 36
5. Hawaiian home life, 40
6. Hawaiian types, 44
7. Heiaus, war canoes and a city of refuge, 48
7. Burial caves, war gods and idols, 52
9. Portion of the Hawaiian government collection, 57
10. Hawaiian types at work and play, 60
11. Ethnographic groups in the Bishop Museum, 64
12. Stone implements and calabashes, 68
13. Objects of native manufacture, 70
14. Hawaiian girls at work and play, 76
15. Hula dancers, 78
16. The surf-riders, 80
17. Miscellaneous Hawaiian pictures, 84

SECTION II—THE GEOLOGY, GEOGRAPHY AND TOPOGRAPHY OF THE HAWAIIAN ISLANDS.

18. Map of the leeward chain of islands of the Hawaiian archipelago,88
19. Views on Midway and Ocean Islands, 90
20. Views on Laysan Island, 92
21. Reefs and islands in the leeward chain, 96
22. Map of the high or inhabited islands of the Hawaiian group, 100
23. Views on Kauai, 102
24. Map of the Island of Kauai, 104
25. Cañons and valleys on Kauai, 106
26. Map of the Island of Oahu, 110
27. View in Nuuanu valley near the Pali showing the peak of Lanihuli, 112
28. Waikiki Beach and Diamond Head, 116
29. Specimens from Diamond Head.
30. Scenery on Oahu, 122
31. Nuuanu Pali, 125
32. Coast scenes on Oahu, 128
33. Formations of geologic interest on Oahu, 130
34. Map of Maui and the Islands of Molokai, Lanai and Kahoolawe, 134
35. Scenes on the windward side of Molokai, 136
36. Halawa valley on Molokai, 140
37. Lanai and Molokai, 142
38. The summit of Haleakala,145
39. Map of the Island of Hawaii, 148
40. View of the windward coast of Hawaii, 150
41. Shore and mountain view on Hawaii, 154
42. Tree moulds in Puna, 156
43. Volcanic scenery on Hawaii, 160
44. Various Hawaiian views, 162
45. Views of Kilauea, 166
46. In and around Kilauea, 170
47. View of the pit of Halemaumau, 174
48. Objects of interest in the crater of Kilauea, 185
49. Views at Kilauea and Mokuaweoweo, 186

SECTION II—THE FLORA OF THE GROUP.

50. Vegetation of the lower and middle forest, **190**
51. Common plants from rocky coast and sandy shores, **192**
52. Striking plants in the Hawaiian flora, **194**
53. Twenty common weeds, **196**
54. Common plants of the fields and roadside (Oahu), **198**
55. Vegetation in the forests, along the streams and the roadside, **200**
56. Kukui and common plants of the lower forest (Oahu), **202**
57. Curious native plants, **206**
58. Plants of the open fields and lower forests on Oahu, **212**
59. The maile and its plant associates on Oahu, **214**
60. Plants on the mountains and along the shore, **218**
61. Ohia and some of its plant associates on Oahu, **220**
62. Plants from near the summit of Konahuanui, Oahu, **224**
63. Common genera of ferns on Oahu, **228**

SECTION IV—AGRICULTURAL AND HORTICULTURE IN HAWAII.

64. Views in tropical gardens in Honolulu, **234**
65. View in the old Government Nursery showing a number of rare exotic plants ,**238**
66. Miscellaneous group of cultivated plants, **240**
67. Various views in Honolulu gardens, **246**
68. Blossoms from a Honolulu garden, **248**
69. Wild and cultivated fruits, **258**
70. Hawaiian fruits, **264**
71. Minor agricultural industries, **270**
72. The milling of sugar-cane, **274**
73. Planting and harvesting sugar-cane, **279**
74. Cattle raising in Hawaii, **282**
75. Four stages in the development of the Hawaiian archipelago, **290**

SECTION V—THE ANIMAL LIFE OF THE GROUP.

76. Hawaiian aquatic animals, **294**
77. Whales and whaling scenes, **298**
78. Groups of Hawaiian birds in the Bishop Museum, **310**
79. Bird life on Laysan, **316**
80. Hawaiian birds of various orders, **323**
81. Six interesting Hawaiian birds, **327**
82. Some song birds of the Hawaiian islands, **330**
83. Some rare and extinct birds of the mountain forests, **332**
84. Six familiar mountain birds, **334**
85. Common Hawaiian birds, **337**
86. The sharks and rays, **340**
87. Fishing scenes in Hawaii, **344**
88. Eels and other curiously shaped fishes, **350**
89. Fishing in Hilo Bay, **352**
90. Fishes at the Aquarium, **356**
91. Choice Hawaiian market fish, **362**
92. Curious and common Hawaiian fishes, **366**
93. Parrot fish, butterfly fish, puffers and their relatives, **370**
94. Gobies, blennies, frog fish, trunk fish and other odd forms, **374**
95. The study of economic insects, **380**
96. Some economic insects, **384**
97. Conspicuous Hawaiian insects, **392**
98. Some common insects and their relatives, **398**
99. Common beetles, bees, wasps, flies, etc., **406**
100. Color varieties exhibited by two common species of land shells, **432**
101. Fresh water fauna on Oahu, **436**
102. Two mollusks used by Hawaiians as food, **442.**
103. Important genera of land shells, **448**
104. Common marine bivalves, **456**
105. Some of the larger common sea shells, **460**
106. Smaller common sea shells, **470**
107. The reef at low tide, **472**
108. Common crabs and barnacles of the coral reef, **474**
109. Collecting on a reef, **478**
110. Small crabs and crab-like animals from the reef, **482**
111. Common corals and coral rock, **486**
112. Corals and reef rock, **488**
113. Miscellaneous marine animals, **490**
114. Common marine plants at Waikiki, **492**
115. Common Hawaiian sponges [Upi], **494**
116. Starfish, sea-urchins and sea-cucumbers, **496**
117. Marine plants and plant-like animals, **498**

Playing Puhenehene—a guessing game, **76**
the nose flute, **76**

Plectromia (variously called Walahee or alahee which *see*).

Plecyopods, 443
Pleistocene, 117
Pliocene, 115
Plover, Golden, 321
  Migration of, 321
  Pacific golden, 310
Plowing (Sugar plantation), **278**
Plumeria (*error see* Plumieria)
Plumier, Charles (Botanist), 253
Plumieria, 252
Plum, Japanese, 266
  Java, 268
Pocillopora, 477

Pod (201). Generally applied to any sort of a seed capsule, but more correctly the pod of a bean-like plant.
Poetry, Examples of Hawaiian, 41, 42, 459
Poets, Hawaiian, 41
Poha, 257
Species of, 257
Pohaku. The general name for stones, rocks, pebbles, etc. Large stones were called pali pohaku; lesser ones pohoku uuku; rough lava, aa; smooth lava, pahoehoe; small smooth stones, iliile, and sand, one.
Pohaku kui poi, **57**
puna (Coral stone), **486**, 477
hookala (*see* Grindstone)
Pohakupele (Worm shell), **460**
Pohuehue, **218**, 197
Poi, 66
board, **60**, 66
Breadfruit, 241
dog, 295
Eating, **76**
Grades of, 67
how eaten, 67
Keeping qualities of, 66
Manufacture of, 66
pounding (group), **64**
pounding on a double board [papa kui poi], **36**
pounders [pohaku kui poi], **57**, **68**, 63
pounders (ring form), **70**
Poinciana, 243
named for, 244
Pods of the, 244
Yellow, 244
Poinsett, Hon. J. R., 249
Poinsettia, 249
named for, 249
Poison god, The, **70**
fang (Cone shell), 455
Fish, 341
Poisonous fish, 373, 367
weed, 341
Points and capes on Oahu, **110**
of interest on Oahu, 131
on Hawaiii, **148**
Sea coast on Kauai, **104**
(*see* Capes)
Polinalina, 199
Polishing calabashes, Method of, 59
stones, 75
Polliwog (Tadpole), 299
Pololia (Jellyfish), 480
(Portuguese man-o'-war), **490**
Pololo, 199, 204
Polygamy, 42
Polygonium glabrumm Willd. (*see* Kamole)
Polynesia ,191, 193, 204, 210, 215, 225, 239, 247, 257
Polynesian, 295, 297, 452
and Hawaiian language, 39
race, Genesis of, 25
Polynesians, 25, 216, 235
Height of, 37
Polyp, 475
Colonies of, 475
Polyzoa, 483
Pomace fly, 421
Pomegranates, 269
Pomelo, 265
Pond, Fish, **270**
life on Oahu, **436**
Mullet, **270**
on summit of Mauna Kea, **151**
Ponds, Lotus, 285
Mullet, 359
(*see also* mullet ponds), 360
Taro, **270**, 63
Poni, 259
Ponohununuhu, 365
Pool, Green, in Puna, **160**
Lava in Kilauea, **174**
Lava in Mokuaweoweo, **186**
Poopa'a, 349
Poou, 359
Pope, Prof. W. T., Photographs by, 14
Popoki, 293
Popolo (*Solanum nodiflorum* Jacq.) is well established in Hawaii. Its small black tomato-like fruits and the tomato-like appearance of the foliage renders it easy to identify. It thrives on waste land, about fences, and by the roadside. The fruit and leaves were much used by the ancient Hawaiians and doubtless possess certain medical properties not appreciated by Europeans.
Popolo, **212**
Popping corn over heat cracks, **184**
Poppy (Mexican thistle), **198**, 204
Population and the food supply, Relation of, 45
of various islands (*see* Length, etc.)
Porcupine fish [Oopu kawa], **370**, 365, 367
Porgie [Mu], **366**, 367
Porites, 477
Pork tabu to women (*see* Women)
Porpoise, 300, 347
Schools of, 300
Portrait of the author (*see* Frontispiece)
Ports and landings on (*see* map of islands in question, *also* Bays, etc.)
Portuguese, 267
man-o'-war [Pololia], **490**, 481
Portulaca [Ihi], 320
Position of Hawaii, **100**
of Honolulu, **110**
of Hualalai indicated, **148**
of Kahoolawe, **100**
of Kauai, **100**
of Kilauea indicated, **148**
of Lanai, **100**
of Maui, **100**, **134**
of Mauna Kea indicated, **148**
of Mauna Loa indicated, **148**
of Molokai, **100**
of Niihau, **100**
of Oahu, **100**, **110**
of Sandwich Islands (*see* Hawaiian Islands) **100**
of the Hawaiian group, **100**
of the Islands, Geographic, 93
Potash in soils, 105
Potassium, Presence of, 117
Potatoes, 284
Early planting of, 284
exported from, 284

Irish, 284
Sweet, 284
Varieties of, 284
Pot-holes at Diamond Head, 131
Pottery not made by Hawaiians, 59
Power, where held, 54
Prayer beads, 207
Prayers and religious rites, **64**
for growth of crops, 63
Praying mantis, 429
to death, 54
to death (A group), **64**
to death, Method of, **64**
Prawns, 468, 469
Precinctive (defined), 193
Predaceous beetles, 416
Predaceous (426). Living on prey, preying on other animals.
Preliminary to a battle, 51
Preopercle [fish] (355). A ridge usually occurring just forward of the large bony flap covering the gills.
Preorbital [fish] (369). A bony prominence before the eye.
Price of Natural History of Hawaii (*see* distributors)
Prickly pear cactus, 209, 269
Pride of India, 211, 244
of the Barbadoes, 244
Priesthood, 50
Priests, 54
Orders of, 50
accompanying the army, 53
Primitive bowling alley, 83
Principal Ports (Hawaiian Ids.), **100**
towns, villages, etc. (*see* Cities, towns, etc.)
Printed by, Natural History of Hawaii, Hawaiian Gazette Co., Ltd., Honolulu
Pritchardia (*see* Loulu)
Procumbent (230). Trailing or creeping on the ground.
Promontory, Kohala, an example of, **148**
Prostrate (199). Lying flat on the ground; not erect.
Protection of fish, 359
Protective coloration, Lizards example of 297
Protovertebrata, 484
Provisions, 30
for a long voyage, 29
Psidium (*see* Guava)
PTERIDIUM AQUILINUM [Kilauapueo] = Pterus aqulina [Kilua]
Pterus aqulina = PTERIDIUM AQUILINUM [Kilauapueo]
Pua. The Hawaiian for a flower. Puaa, a hog.
Puaiohi, **330**
Puakahala (Cavalla), **366**, 364
Puakala (Mexican poppy), **198**, 204
Puakeawe, 225
Puakeawe = Pukeawe. A shrub (*Cyathodes tameiameia* Cham.) common on the mountains of the group (*see* text). Dr. Emerson states that it was with the smoke of this bush that the ancient kapu-chiefs are said to have smudged themselves before mingling with the people on equal terms. *Cyathodes* is sometimes made a sub-genus in the genus *Styphelia*.
Puala (Surgeon fish), **370**
Pualele (Sow thistle), **196**
Paulu, 349, 372
Public policy, forwarded by marriage, 45
Pudding stick tree, 244
Pu, 449, 452
leholeho (Spotted conch), **470**
Pueo (Owl), 336
Puffers, 365, 367
Common, **370**
Sharp-nosed, **370**
Puhenehene, Playing, **76**
Puhi (Moray), **350**, 349, 355
laumili, **350**, 361
kapa, 361
kapa (Moray), **350**, 361
laumili=puhi laumelo
uha, 355
Puhiki'i, 349
Pukamole=Kamole
Pukaoaa point, 143
Pule, Ancient, to the corwy, 459
Puleho, 457
Pulu. Any soft substance, as for example, the mass from which the tapa was made: hence the name of the material that grows on and is collected from certain large ferns (*Cibotium* spp.) and used to some extent as down for pillows, etc.
Pulu, Uses of, 222, 228
Pumice (limu) is usually a form of obsidian (which *see*) and contains a large per cent of silica. It is usually the froth-like lava ejected from volcanoes and has a loose spongy or cellular structure which is produced by the escape of gas or steam while the lava, of which it is formed, was becoming consolidated. Light specimens will float and are carried far and wide by the sea: small pieces are occasionally picked up by sea birds, especially the albatross. It was much used by Hawaiians for polishing, and was also used in the last stages of preparing a pig for baking. Pumice is in reality porous volcanic glass, the pores being small.
Pump drill, Hawaiian, 75
Puna=General name for Porites, **486**
Puna, Green Lake in, **160**
Lava tree casts in, **162**
Lava 'tree moulds,' **156**
Punahou Academy, Night-blooming Cereus at, **246**, 254
Punaluu, Underground stream at, 182
Punchbowl Hill, 115, 121
Points of interest at, 129, 130, 131, 132
Pupa (385). The third and usually the resting stage of insects which undergo complete metamorphosis.
Puonionio (Partridge tun), **460**
Pupu, 449
alapii, **470**
Chinese, **436**
ole (Hairy triton), **460**, 450
moo, **470**
('Purple shell'), **460**
puhi (Sun-dial shell), **470**
Pupukeawe, 230
Purging Cassia, 244

Purple-hinged scallop, **456**
shell [Pupu], **460**
shell, Spotted, **470**
scale, 265
wreath, **250**, 248
Purpura, 449
Purslane [Ihi], **196**, 286, 287
Pussly, 287
Puu, 226
kukui, 138
olai (Sharp-nosed puffer), **370**
Waawaa, 155
Puuhonua (City of refuge), **48**
Puunene spider, 410
Pyramid shell, **470**, 463
Pyrus (*see* Sand Pear, *also* Pear)

Q

Queensland nut (*Macadamia ternifolia* Muell). More properly the Australian nut is a medium sized tree producing a round smooth, shiny brown nut, with a very hard shell. The kernal resembles the filbert and may be eaten raw or roasted. Other species of the genus also occur in Hawaii, in most instances having been introduced by Mr. E. W. Jordan.
Quashy-quasher, 252
Quilted triton, **460**, 450

R

Rabbit Island, **128**, 293
Rabbits, 293
Raceme (248). A flower cluster in which one-stemmed flowers are arranged along the side of the main stem.
Racing in the surf, 80
Rail, Extinct, **327**
Flightless, 314
Flightless, How killed, 293
Flightless Laysan, 318
Hawaiian, **327**
Raillardia (*see* Kupaoa)
Railroad ties, 215
Railway on Oahu, **110**
distances (*see* Overland Distances)
Rainbow Falls (Hawaii), **160**, 176
Rainfall. Precipitation in the islands varies greatly from place to place and year to year. At Honolulu statistics (U. S. Weather Bureau) gives the rainfall varying in ten years from 16.99 (1905) to 30.13 (1909) inches. On Tantalus (three miles distant) in 1905 it was 99.68 inches. On Hawaii in Hamakua, at 1200 feet elevation, it was 260.67 inches (1907). At Waikea, in the rainy Hilo district (1907) it rained 333 days; at Waianae, a dry district on Oahu, it rained on 60 days.
Rain forest, Characteristic growth in, **218**
forest, Lichens in the, **194**
forest, Typical view in, **190**
heiaus, 50
heiaus (*see* Ipu o Lono)
tree, 242
Ramble in a Honolulu Garden (Part one), 231
in a Honolulu Garden (Part two), 243
Ramie, 217
Ranch scenes on Hawaii, **282**
Range, Koolau, 211
Waianae, 211
Rank and hereditary position, 54
Descent of, 46
Marriage among persons of, 45
Positions of, How descended, 45
Rare and extinct birds, Some, **332**
exotic plants (Government Nursery) **238**
fruits in Hawaii, 255
Hawaiian birds, 333
Rarest Hawaiian bird (*Chætoptila*), 335
Raspberries, Native, 256
Rat, Black, 291
Brown, 291
nests, 292
Long-tailed, 292
Norway, 291
Short-tailed, 292
Tree, 292
Rats as plague carriers, 292, 401
Grey, 291
Hawaiian, 291
Species of, 292
Tree, 235
Rats-foot (*Lycopodium* sp.) is a common moss-like plant common about the outskirts of the forests where it often forms thickets after the manner of the staghorn fern. The two species occurring here are widespread over the globe.
Rathburn, Dr. Mary J. (Crustaceologist), 12, 469
Ratoon (261). A shoot or sprout coming up from the root of a plant after it has been cut (*also* rattoon).
Ratoons, Pineapple, 261
Rattlebox, **196**
Rattle shells, 449
Rattles [Uliuli], **70**
Bamboo, 82
Seed, 82
Rattoon (*see* Ratoon)
Ray, Spotted sting, **340**, **347**
Sting, **340**
Rays, 347
and sharks, **340**
Sting, 347
Eagle, 347
Raw fish, 355, 365
Recruits for warfare, 51
Red birds, Hawaiian, 329
-bug family, 426
-fish, 354, 371, 373
-footed body, **310**, **316**
-rush flour beetle, 395, 405, 418
sandalwood, 203
-scale, 391
spiders, 401
-tailed tropic bird, **310**, **316**, 309
Reed, Miss Minnie (Marine Botanist), **502**
-warbler, Chinese, 308
-warbler, Laysan, 319
Reef at Honolulu Harbor, 211
at low tide, **472**
-building corals, **486**, **488**, 476
collecting, **478**
Dowsett, **88**, 97
fishing, **344**
Miscellaneous animals from the, **490**

Maro, **88**, 97
Pearl and Hermes, **88**, **96**, 94
rock, **488**
Tide pools in the, **472**
Reefs, Coral, elevated, 115
Coral, on Oahu, **110**
Reflex action, Example of, 346
Reforesting. Efforts have been, and are being, made to restore forests in localities where they have been depleted, or have disappeared. Several of these efforts have not only resulted in great benefit to the localities, but are serving as object lessons, showing the need of enclosing and defending the existing forest areas. This work is now carried on under the able direction of the Hawaiian Bureau of Agricultulre and Forestry.
Regeneration of lost parts, Examples of, **491**
Relief map of Kauai, **104**
map of Hawaii, **148**
map of Maui, **134**
map of Oahu, **110**
Religion and tabu, Relation of, 47
of the Hawaiians, 47
Remora, 367
Reservation, Hawaiian Island Bird, **93**
Resin, 211
Rhapis palm, **240**
palm, peculiarity of, 237
Rice, 276
Area under cultivation, 276
birds, 277, 304
birds, Damage by, 305
birds, Protecting crop from, 305
Diseases of, 277
farmer, Chinese, **282**
fields in Waipio valley, **154**
Harvesting of, 277
Hawaiian, 276
how planted, 277
Irrigation of, 277
Method of cultivation, 276
mill, 279
Oriental method of cultivation, 276
paddy, 276
Pests of, 277
propagation, 276
related to, 276
Thrashing of, 279
Varieties of, 276
weevel, 395, 405, 418
Wild, 277
Yield of, 276
Riding the surf, 86
Right whale, 301
Ring form poi pounder, **70**
-necked pheasant, 307
Rio de Janeiro, 279
Ripe rot, 265
Rise and fall of lava column, 164
River(s) (*see* Streams)
and streams on Kauai, **104**
Meandering, Example of, **106**
Hanalei, **106**
on Oahu, **110**
view on Kauai, **102**
Road, Fern stem, **200**
material, 129
Roads on Kauai, **104**
on Hawaii, **148**
on Maui, **134**
on Oahu, **110**
Roadside, Scenes along the (Hawaii), **200**
Robes, Feather, 75
of state, 75
Rock, Building, 129
Coral, **486**, 129
crabs, **474**, 469
lobster, **474**, 469
oyster [Kupakala], **456**, 446
urchins, 487
wasp, Black, 414
Rocky coast, View on a (Oahu), **122**
coasts, Plants from, **192**
Hill, 220
Hill, Age of, 124
ledge at Laysan, **92**
shore-line (Oahu), **130**
stream, Typical, **28**
Rocks (*see* Hawaiian Igneous Rocks)
Romero (Pilot fish), **366**
Root-casts at Diamond Head, **118**, 131
-rot, 265
Roots, Curious lotus; 285
Fossil, **118**
Rope, Banana fiber, 281
Cocoanut, 236
of olona, 217
Ropes of ieie, 211
Ropy lava in Kilauea, **174**, **186**
lava [pahoehoe], **162**
Rosa de la Montana, 248
Rose aphis, 389
apple, 267
banana, 259
-bay, 252
beetle, Fuller's, 394
-laurel, 252
Mountain, **250**, 248
-scale, 391
South sea, 252
Roselle (*Hibiscus Sabdariffa* Linn.) Is widely cultivated in the tropics, including Hawaii, where its pleasing acidulous rose-red calyxes are used for tarts, jellies, etc. A cooling drink can also be made from them. The bark yields a fiber elsewhere known as roselle-hemp. In the West Indies the plant is known as Indian or red-sorrel. It is a true *Hibiscus* coming originally from the East Indies.
Rotary drill, how made, 75
Round clam, 445
-up on Hawaii, **282**
Rough rock urchin [Haukeuke], **496**
lava (a-a), **162**
Royal Agricultural Society, 297
birth, Drum used to announce, **64**
emblem, 77
flower, Ilima a, 203
palm (*see also* palm), **246**, 232, 233
palm, **246**, 232
palm, Blossoms of the, 232
palm, Introduced from, 232
sport, 292
tax, 56

Rubber, 281
Assam, 283
Hawaiian, 283
Hevea, 283
India, 245
Introduction of, 281
Para, 283
producing, Euphorbia, 283
producing trees, 283
Runners (Fish), 365
Long distance, 83
Rush=Bullrush, **198**
Rush Club, **198**
Russet oranges, cause of, 265
Rove beetles, 416, 417

S

Sacred banian, **240**
kamani grove (Halawa), **140**

Sacrifice, Human. While sacrifice was an important part of formal worship in old Hawaii, human sacrifices were offered only on special occasions. It was, however, the supreme act of ancient worship in the important heiaus of the highest class. Such occasions as the launching of a war-canoe, the building of a house for a chief, the sickness of a king or queen, the securing of a new idol, or the burial of a chief, called for a human offering to the appropriate gods. The victims were always males and were either taken in war or persons rightly or wrongly accused of violating some of the innumerable tabus. The mode of securing the victim was usually by secret assault, commonly by a blow with a club, though other methods were employed. The Mu was the person whose duty it was to secure the required sacrifice. The dead body of the person so slain was dragged to the heiau and laid on the altar [lele] for sacrifice, together with hogs, dogs and other offerings—there to putrify. It is stated that as many as eighty persons were sometimes immolated at once."

The last human sacrifice in the islands occurred in 1807. Queen Keopuolani was then dangerously ill. The priest asserted that her illness was caused by the gods who were offended by certain men eating tabu cocoanuts. Eight men were at once seized by the king's orders and offered in the heiau that then stood at the foot of Diamond Head.

Sacrifice to Pele. The goddess of volcanoes was much feared on Hawaii. When an eruption took place at Kilauea it was the custom to make offerings to her of hogs, etc., which were thrown into the liquid lava. Devout persons sometimes gave the bodies of their relatives to Pele by throwing them into Kilauea that they might join the volcanic deities and in this way befriend the family. The ohelo berries were the usual offering to Pele.

Saddle oysters, 444
Sadleria (*see* Palahola)
Sago palm, 237
Sailing vessels, Fishing from, **344**
Salangore cane, 273
Salfemane (*see* Hawaiian igneous rocks)
Salmon, 378
Salt, 129
Effect of on cane, 271
from Salt Lake, 74
Lake crater, 115, 132
Lake crater, Age of, 124
manufacture, 73
marsh beetles, 418
Samang, 242
Sanctuaries, Hawaiian, 51
Sandalwood, 217
Bastard, 210, 222, 226
Bastard (*see* Aaka, *also* Naio)
Beach [Iliahi], 192, 199
damaged by goats, 221
Discovery of, 219
Odor of, 221
Red, 203
roots of used, 221
uses of, 219
Sand beach, **218**
Sand, Black, 117
Building, 129
-burr, 287
crab, **496**
concretions at Diamond Head, 131
dunes on Maui, 139
dunes on Oahu, **122**, 131
grass, **90**
hills, How formed, **90**
hoppers, 409, 468
island, View on a (Laysan), **294**
island, Vegetation on a, **90**
Olivine, 129

Sand pear (*Pyrus Sinense* Lindl.) bears an apple-like fruit, 2 inches in diameter, with a sandy, tough, flesh, which has a very fine flavor when baked. This ornamental tree is characterized by dark green, apple-shaped leaves, pointed at the tip, edged with fine teeth; the flowers are large and white. Although not common in the islands, the sand pear is well established.

Sand root casts, **118**
Sanderling, 321, 324
Standstone, 129
aëolian, **140**
boulder, Erosion of, **136**
eroded by sea waves, **142**
Laminated, **140**
cliffs at Moomumi, **140**
Sandwich Islands, Position of (*see* Hawaiian Islands), **100**
San Francisco, Distance to, 101
Route from to Islands, **100**
Sapodilla, 266
Sapota pear, 266
Sargassum sp. (fig. 15), **498**
Sassafras, 262
Sausage-like roots of lotus, 285
-shaped animals [Loli], 491

Sausage tree (*Kigelia pinnata*) is a curiosity wherever grown. It is a large tree with whitish bark and spreading branches, coming originally from Africa. The fruit, rough and green in color, is sometimes two feet in length and hangs from a long stalk. It has a corky rind, filled with pulp and numerous rounded seeds. In Nubia this tree is held sacred, and religious festivals are conducted under it by moonlight. A few trees, doubtless introduced by Dr. Hillebrand, may be seen in old gardens; a fine specimen is in the grounds at the Queen's Hospital in Honolulu.

Savaii, center of dispersal, 26

Scab, Lemon, 265
Scad, Big-eyed, **362**
Scale-bugs, 391, 427
Florida Red, **384**
insects, 391, 425
Lantana, **384**
on citrus and palm leaves, **384**
Pineapple, **384**
Purple, 265
Scallop, **456**, 443, 444, 445
Purple-hinged, **456**
Scarabæids, 417
Scavenger beetles, Water, 416
Scene or Scenery, Plantation, **274**
in middle forest zone, **200**
Miscellaneous fishing, **344**
Ranch, **282**
Waipio falls, **154**
on Molokai, **140**
on Hawaii, **150**, **156**, **170**
Volcanoes made (Haleakala), **145**
Whales and whaling, **298**
Scented woods (*see* Iliahi, Naio; there are six or eight rarer species in the Hawaiian flora.)
Scents (*see* Perfumes), 221
Scents for tapas were made from the following plants—awapuhi, iliahi, kupaoa, maile, olapa, etc.
Schlemmer, Max, 322
Schooner Guano trade, **92**
Science and legend agree, 91
Scientific names (*see* Nomenclature)
names, arrangement of, 9
names, why used, 10
Scorpion, **398**, 407, 409
fishes, Venon in, 368
fish [Nohu], **374**, 368
Scorpions, 407
False, 408
Large species from, 407
Screw pine [Lauhala], **190**, **194**, 221, 252
Scraping olona (Group), **64**
Scrapers of bone, shell and wood, 75
Olona, 73
Sea-anemonie, **490**, 473, 475, 476
bass, Characteristic of (*see* Snappers), 368, 369
-beach, Halawa valley, **140**
-beaver (Heart urchin), **493**
Birds of the, 308
bird squabs, 311
biscuit, 487
caves at Black Point, 131
cliff, Example of Oahu, 122
cliffs on Hawaii, **154**
-cucumber [Loli], **496**, 485, 491
devil, 347, 369
"ear" [Pepeiau], (fig. 1), **492**
egg or Sea-urchin [Wana], **496**, 487
end of Olokuai mountain, **136**
erosion, Example of, **142**
Erosion by the (Sandstone), **142**
-fans, 479
fights (*see* Naval battles)
formed cliffs on Hawaii, **150**
hares, 467
"hedge-hog," 485
-horse, **350**, 365
Island cotton, 281
-money, 481
morning-glory, 197
-moss as perfume, 222
-moss, Common, at Waikiki, **492**
mushroom, 479
perch [Aholehole], **366**
-pens, 475, 479
-plumes, 479
robin (Gounard), 357
shells, Common, **460**
-shore at Wailau valley, **136**
-shore, Plants by the (Lauhala), **194**
-shore, Crab fauna of the, **474**
-shore, Palm trees on the, **150**
-shore, Plants from, **192**, **218**, 189, 201
-shore, Shells from the (Part one), 440
-shore, Shells from (Part two), 453
slugs, 467
-slug, Dye from, 69
snakes, 299
snail shell [Kupee], **470**, 465
snail, Little, **470**
-snappers, 367
-squirt, **490**, 484
turtles [Honu], **294**, 299
turtle, Barnacles on, 475
-urchins, **496**, 485
-urchin, Dye from, 69
-urchin, Heart, **478**
-urchin, Masticating organ of, **496**
-urchin, Test of a, **496**
Various animals from, 291
worms, 497
Seaweed, 500
How to collect, 500
Seal, 303
Hawaiian, **294**
on Pearl and Hermes Reef, **96**
Sealskin, 304
Second plant zone, 201
Secondary craters in Haleakala, **145**
craters on Hawaii (indicated), **148**
craters on Kauai, **104**
craters on Maui, **134**
craters on Oahu, 110
craters (Oahu), Time of formation, 220
volcanic cones on Kauai, 105
Section **I**, page 25; **II**, 89; **III**, 189; **IV**, 231; **V**, 291
Securing fish bait, 343
Sedge (199). A grass-like plant belonging to the large genus *Carex*. More generally the name is applied to the whole family *Cyperaceæ*.
Sedge, **192**, **198**
Seed cane, Planting, **278**
rattles, 82
Seeds for leis, 207
Lotus as food, 285
Sein needle, 75
Seins, 339
damaged by, 353
of olona, 217

Senna, **250**
Sensitive plant, 287
Separation among Hawaiians, 45
of the Hawaiian Islands, **290**
Serricorne beetles, 417
Serriere, Dr., 207
Sessile [Bot]. Leaves without any foot-stalk; the leaf joined to the branch without a foot-stalk.
Sessile barnacles, 473
Sex relations among Hawaiians, 42
relations, Influence of foreigners on, 42
Shaddock, 265
Shade in Honolulu streets, 232
Shark, Blue, **340**
Dog, **340**
Fish attached to, 368
fisherman, Kamehameha I, a great, 343
fishing, **344**
fishing in ancient times, 343
fishing in modern times, 343
Shark gods. There were a number of shark gods usually worshipped by fishermen. Their small heiaus were numerous and still stand on almost every important headland throughout the group. They were often called Kuula, the name of an important fish god, and in them the shark gods were worshiped. When Kuula would not give the people fish they prayed to Hina, his wife, to intercede for them.
god, Respect for the, 346
Hammer-head, **340**, 346
'holes,' 346
-hook (*see* Kiholo), 343
Mackerel, **340**, 346
Man-eater, **344**
oil, 346
pens, 341
skin, use of, 82, 346
Snaring, 346
stew, Story of a, 345
stories, 345
tabu to women, 346
teeth, 346
teeth, uses of, 74, 81
Thrasher, **340**
Sharks and rays, **340**
Bones of extinct, 345
Man-eater, 345
Species of Hawaiian, 343
teeth sword, 81
Tiger, 345
teeth, use of, 62
Sharpening stones, 75
Sharp-nosed puffer [Puu olai], **370**, 367
Shearwater, 309, 318
Christmas Island, **310**
Wedge-tailed, **310**, **316**
"She dragon" tree, 211
Sheet flow structure shown on Molokai, **140**
lava flows, Examples of, **122**
Sheep, 287
-head maggot fly, 387
introduced, 295
-maggot fly, 387, 419
Shell, Ark, **456**
Augur, **460**
Banner, **470**
bracelets, 465
Bubble, **470**
Dove, **470**
Eulima, **470**
Fish-basket, **470**, 242
Harp, **460**
Ham, **456**
Hawaii top, **460**
Heart, **456**
Hermit, **460**
Horn, **470**
Horse-hoof, **470**
hunting, 437
Jingle, **456**
Ladder, **470**
Little emerald, **470**
Lucina, **456**
Measure, **470**
Mitre, **470**
Mottled periwinkle, **470**
Mulberry, **470**
Moon, **470**
Niihau, **470**
Ornament, **470**
Pyramid, **470**
Sea snail, **470**
Slipper, **470**
Spindle, **460**
Spotted purple, **470**
Stair-case=Sun-dial shell, **470**
Sun-dial, **470**
Tankard, **470**
Tellen, **456**
Top, **470**
Turban, **460**
Umbrella, **460**
Violet snail, **470**
Worm, **460**
Zebra dove, **470**
Shells as curiosities, 441
as emblems of mourning, 465
Brackish water, 439
Carnivorous, 447
Common sea, **460**
cooked in an imu, 465
Land, Distribution of explained, **290**
Fresh water, 431
Fresh water, of Oahu, **436**
from the sea-shore (Part one), 440
from the sea-shore (Part two), 453
for an aquarium, 447
Herbivorous, 447
Land, 431
Land ,Important genera of, **448**
Pleasure in collecting, 440
Sheltered shore-line, Example of, **116**
She-oak, 237
Shields, Spears used as, 79
Ship, Full-rigged whale, **298**
worm, **490**
Shoal, French Frigates, **88**, **96**, 97
Frost, 97
Gambier, 94
Shoals, Islands, etc., Map of, **88**

Shore birds Group of, 310
Birds of the, 320
crabs, How to identify, 471
plants, 192
views on Oahu, 128
-line, Embayed, 270
-line, Hamakua, 150
-line (sheltered), Example of, 116
-line, Trees on, 150
scene on Kauai, 102
Short-horned grasshopper, 388, 429
-tailed Crustacea, 469
-tailed rat, 292
Shoveler duck, 328
Shrimp, 436, 376
as bait, 343
baskets, 341
Fresh water, 440
Shrimps, 468
Shrub (195). A woody plant living from year to year and of considerable size.
Shrubs and vines, 248
Siberia, 296
Sicyos (*see* Kupala)
Sida, Common, 196
Side trips from Kilauea, 181
Sideroxylon (*see* Alaa)
Silk culture, 399
oak, 248
Silkworm, 397
food of, 267
Silversword [Ahinahina], 206, 146, 227, 229
Green, 229
Silver wattle, 248
Silverfish, 403, 430
Silvery lemon, Cause, 265
Singing, Hawaiian, 42
Single-celled animals, 499
Single canoes, 80
Sisal, 280
Curious blossoms of, 280
Gathering, 270
plantation, 270
weevel, 395
when introduced, 280
Skates, 347
Skeleton, Coral, 475
Whale (in Bishop Museum), 298
Skeletons of sponges, 500
Skin beetle, 417
Skinks, 296, 297
Skirt [Pa-u], 57
Ki leaf, 78
Lauhala leaf, 78
Skip-jacks [Aku], 344
beetle, 417
Catching, 344
Skylarks, 143, 307
Introduced, 307
Song of the, 307
Slater or pill-bug, 398
Slaves, how used, 343
Sled [papa holua], 57
'Sleeping' trees, 242
Slides, Papa holau, 86
Sliding game (*see* 'Summer tobogganing')
Slings used in warfare, 81
Slip-noose, a weapon, 81
Slipper shells, 462
Slips, Pineapple, 261
Slop bowl, 70
basins, 61
jars, 63
Slug(s), 439, 441
Black, 439
Sea, 467
Small cones in Kohala range, 149
cones on Hualalai, 152
cones on Mauna Kea, 151
crabs and crab-like animals, 482
craters on Haleakala, 143
farming industries, 270
farming, taro growing, 270
farming, rice plantation, 270
industries, taro growing, 270
industries, cattle raising, 282
periwinkle, 470
Smilax, Native, 213
Smith, Prof. Jared G. (Agriculturist), 284
Smoke from trash-fire, 270
Smooth (Ropy) lava [Pahoehoe], 162
Snail(s), Chinese, 436
Edible, 438
Tree, 431
Sea, 465
Violet, 470, 463
Snake-head cowry, 470, 458
mullet, 377
Snakes, No, in Hawaii, 299
Sea, 299
Snaring fish, 242
shark, 346
Snapper [Opakapaka], 362, 369
bug, 417
Snout beetles, 418, 419
Rose, 394
Snow. On the high mountains of Hawaii and Maui snow falls in winter, descending in some cases to the upper forest belt. Frost rarely occurs in winter below 4000 feet.
Snow on Hawaiian mountains, 151
on Mauna Kea, 154
Soap plant, Hawaiian, 204
Social wasps, 414
Soils of Kohala, 149
Plant food in, 105
Sugar-cane, 273
Solanum (*see* Popolo)
Soles, 371
Solidified dunes, Erosion of, 142
lava (Recent), 166
Solitary bees, 415
wasps, 414
Song birds of Hawaii, Some, 330
of birds (*see* species in question)
Songs, Hawaiian, 41
Soothsayers (*see* Nana uli)
Sooty mould on lemons, 265
tern, 310, 312
with eggs,, 316
Sorcerer, 64
Sorcery, Gods of (*see* Uli)

Sorghum, 285
Sorosis (defined), 261
Soundings in Pearl Harbor, 110
Sources of the flora, 191
The author's, 11
Sour sop, 266
South America, 191, 248, 249, 268, 383
Pacific, 235, 266, 271, 444
sea rose, 252
Seas, Map of, 100
Sow-bug, 436, 408
thistle [Pualele], 196
Spalding, Irwin (Collector of Mollusca), 12
Spanish, 268
jasmine, 250
needles, 196, 227
Span-worms (Loopers), 397
Sparrow, English, 304
Chinese, 304
Sparrows. Albinism among the English sparrows is quite common. Occasionally birds that are almost white will be seen in Honolulu.
Spathe (249). A bract which, with others, wraps the unfolding flower.
Spatter cone, 180
at Kilauea, 179
how formed (shown), 184
"Little Beggar," The, 184
near Halemaumau, 184
Spatulate (251). Shape like a spoon, or spatula; the broad end at the outer end of the leaf.
Spear [Newa], 44
practice, 84
throwing, 83
Spearing fish, 341
Spears, 57, 79, 215
used as shields, 79
Special taxes, 56
Specialization among Hawaiian birds, 338
Specific characters (*see* species in question)
Species (*see* Nomenclature)
of fish, Number of, 351
of native woods, Number of, 226
of, Number (*see* genus, family or order of question)
of plants, Numbers of, 191
of rats, 292
Specimen of a blow hole, 184
Sperm whale, 298, 301
Sphagnum (229). Any of the peat or bog mosses, hence applied to a moss-grown bog.
Sphinx or Humming-bird moth, 398, 399, 421
of the Pacific, 115
Spider(s), 409
as household pets, 410
House-, 409
Red, 401
shell, 457
Spike [Bot] (208). Flower clusters in which the sessile flowers are arranged similarly to those in a raceme.
Spine [Bot] (205). Hardened branches or tips of stems called spines or thorns.
Spindle shell, 460, 450
Spineless raspberry, 256
Spiney-rayed fishes (355). Fishes with one or more hard rays or spines in some of the fins.
Spiney rock shells, 449
Spiral shells, Class of, 441
sun-dial shell, 463
Spire (461). The turns of a shell forming the apex and including all but the last or largest turn.
Spirit as 'a double,' 49
Spirits, Abode of the, 49
returned to the body, 49
Spittoons, 70
Spondias (*see* Hog plum)
Sponge culture, 499
Substance of, 500
Sponges, 499
Common Hawaiian, 494
inhabited by, 499
of commerce, 500
resemble plants, 499
Sport, Royal, 292
Shark fishing as, 344
Shooting flying-fish, 355
Sports, 83
Spear throwing, 84
Spotted augur shell, 455
conch [Pu leholeho], 470, 457
cone shell, 45
deer, 296
purple shell, 470
sting ray [Hihimanu], 340, 347
Spouting horn, 118
horn at Black Point, 131
Springtails, 430
Springs (*see* Fresh water springs)
Fresh water ,in the sea, 127
Sprouting-leaf plant, 254
Spurge, Garden, 196
Squabs, Sea bird, 311
Square-headed grasshoppers, 429
Squid (Octopus), 472, 302
-hook, Cowry shell as bait on, 458
Dye from, 69
fishing, at low tide, 472
-hook sinkers, 68
ink (*see* Pikopiko)
spawn (*see* Alaalahee)
spear, 472, 341
Squirrel-fish, 371
[U-u], 362
[Alaihi], 366
Squirt, Sea, 490, 484
Stag beetle, 417
Stable-fly, 387, 419
Stages in geologic development of Hawaii, 290
in geologic development of Kauai, 290
in geologic development of Maui, 290
in geologic development of Oahu, 290
Stag-horn fern. A name usually applied to certain introduced species of the genus *Platycerium* commonly grown in baskets; so-called because the fronds are forked like a stag's horn. The name is also applied to native ferns.
Staghorn fern [Uluhe], 194, 228, 223, 253
Stair-case shell (Sun-dial shell), 470, 464

Stalactite caves, 179
Stalagmites, 179
Stalked barnacles, 468, 473
corals, 479
Stamens (216). Slender knobbed stalks within the circle of petals of a flower.
St. Andrew's Cathedral built of, 129
Star apple (*Chrysophyllum canito* Linn.). The tree is a native of the West Indies, but is quite common in Hawaii, having been introduced at an early date. It may be identified by its leaves which are a handsome green, with the under surface dull golden. The tree, 20 to 30 feet tall, bears abundant symmetrical fruits, larger than a peach, which vary in color from white to purple, as does also the flesh. The fruit is delicious, if allowed to ripen thoroughly, and when cut in cross-section shows a star-shaped core, whence the common name. There is also a white variety which bears larger fruit that are pale green flushed with purple.
Starch, produced from, 284
Starfish [Pea], **496**, 485, 487
Arm of a, **496**
Brittle, **496**
Station on Midway Island, **90**
Steam brick, 129
cloud over Halemaumau, **166**
cracks at Kilauea, 177
Steamship lines to Hawaii, **100**
Steel-blue ladybird, 394
Steering a course by the stars, 30
Stejneger, Dr. L. (Herpetologist, Biologist), 297
Stephanotis, 248
Stick-tight grass [Piipii], **196**
Stilt, Hawaiian, **310**, **327**, 325
Sting ray, **340**, 347
Stinging cells (Jelly fish), 480
Hymenoptera, 412
Stock food, Algaroba beans as, 243
Stokes, John F. G. (Polynesian Ethnologist), 291
Photographs by, 14
Stone adz, 74
age, Ancient Hawaii in, 74
bone and wood, uses of, 75
carvings in caves, 129
carving tools, 74
cups, **68**
files, 75
hammers, 75
house, 58
idols, 49
Implements of, 74
implements, Group of, **68**
lamps, **70**, 62
lilies, 497
mortar, **70**, 63
'moss,' 129
pestle, **70**
poi pounders, 63
tools, used in house building, 58
Stones, Polishing, 75
Sharpening, 75
Uses of, 63
Stony corals, 476
Stormy petrel, Hawaiian, 304
Strand plants, 195
Street tree, Monkey-pod not suited as, 242
Streets, Trees in Honolulu, 232
Striking plants in the Hawaiian flora, **194**
Striped fish (Squirrel fish), 372
Striped surgeon fish [Manini], **362**
Stripping and cutting sugar-cane, **278**
Stream, Wailua, **102**
Streams and rivers on Kauai, **104**
Animals of the, on Oahu, **436**
Birds of the, 320
on (*see* Map of island in question)
Vegetation along the, **200**
Strenuous dragon-fly, 424
Strongholds in warfare, 51
Strong's Island, Cocoanut trees from, **92**
Struggle for existence among Hawaiians, 45
on Laysan, 313
'Stump leg,' Old (Plover), 322
Styphelia (*see* Puakeawe)
Sub-aërial erosion, Example of, **136**, 131
Submarine base of the group, 123
gardens, 476
Submergence in Hawaiian Islands (*see* Depths of Inter-Island Channels)
Subsidence, Biologic evidence of, 124
Evidence of on Oahu (Embayed shoreline), **270**
of the Hawaiian group shown, **290**
of Oahu, Evidence of, 220
Subterranean water, 127
Suckers [Bot]. Plants coming up from branches or roots under ground.
Suckers, Pineapple, 261
Sucking-fish, 367
Sugar (*see also* sugar-cane), 271
apple (*see* Sweet sop)
Grades of, 275
industry, 271
Manufacture of, 273, 275
mill, Views of, **274**
palm, 237
plantation, General view of, **278**
Process of producing, 275
Sugar production (1912) was 1,205,165,000 pounds, valued at $49,961,509.00, and 1,734,318 gallons of molasses, valued at $72,241.00, making the total sugar production valued at $50,038,750.00. The 1913 crop was 546,798 tons.
Raw, 275
Refining of, 276
Sack of (weight), 275
when first made, 273
Sugar-cane, 67
Age of maturity, 273
Annual yield of, 271
aphis, 389
Area for, 271
borer, **380**, 383
Cultivation of, 273
Cutting and stripping, **278**
Diagram of, Mill process, **274**
Factors in production of, 271
Gathering, **274**
Harvesting, **274**, 273
in blossom, **278**

insects, 388
Introduction of, 271
Irrigation of, 273
Hauling, **274**
leaf-hopper, 381, 427
leaf-roller, 388, 395
leaves, 59
mealy-bug, 389
Milling of, 275
Pineapple disease of, 261
plant, Description of, 273
Planting and harvesting, **278**
Propagation of, 273
related to, 273
Scenes on a, Plantation, **274**
soils, 273
Stripping of, 273
Unloading, **278**
Use of, 79
Varieties of, 273
yield, how increased, 273
Yield per acre, 271, 389 (*see also* Sugar production)
where cultivated, 271
Work of, borer, **380**
Sulphur bank at Kilauea, **170**, 177
fumes, Effect of on vegetation, **170**
Summer [Kau] (*see* Hoilo)
tobogganing, 86
Summit of Mauna Kea, **154**
Sun-dial shell [Pupu puhi], **470, 463**
Sun-fish, 377
Surf bathing, **80**
along the coast, Kaena Point, **122**
board [papa hee nalu], **80**, 86
board, Shape and size of, **80**
board, Standing erect on the, 86
canoeing, **80**
near Waimea Bay, **128**
Surface of a lava flow, **160**
Surgeon fish [Puala], **370**, 372
Striped, **362**
Surmullets, 372
[Weke ula], **362, 366**
Surinam cherry, 267
Suttonia (*see* Kolea)
Swezey, Prof. Otto H. (Economic and systematic entomologist), 12, 411, 414
Sylvan (210). Pertaining to the woods or forest.
Syrphus flies, 419
Syrup, Sugar-cane, 275
Sweeping, **76**
Sweet-potato, 197
horn-worm, 399, 421
Propagation of, 284
weevil of, 418
Sweet-potatoes, 67, 284
grown by Hawaiians, 284
Varieties of, 199, 284
Sweet scented banana, 259
sop, 266
Swimming bells, 480
Swine, 287
Swordfish [A'u], **366**, 373
Sword of shark teeth, 81

T

Tabu and religion, relation of, 47
and the kahunas, 46
colors, 73
Fishermen's, 73
ground, **48**
Religious and political nature of, 46
Rigorous nature of, 47
Sharks were, 346
The, 46
The foundation of, 46
where practiced, 46
Tabued persons, places, objects, 47
Tabus, Fishing, 399
for women, 46
Nature of, 46
Tadpoles, 299, 440
Transformation of, 299
Tahiti, 260, 262, 263
apple [Wi], **264**, 266
Tails of lizards, Curious facts about, 297
Tallow (*see* Hides), 287
Talus debris on Molokai, **136**
Tamarind, 245
butter, 245
Drink from, 245
Wood of, 245
Tan bark, 213
Tangs, 372
Tankard shell, **470**, 450
Tanna cane, 273
Tantalus, 115, 220
Age of, 124
Ash eruption from, 121
Tapa [*see also* Kapa]. The following native plants were used in the manufacture of tapa or bark cloth: Akala, hau, maaloa, mamake, olona, poulu, wauke, and later the introduced mulberry.
Tapa, **57**
Tapa beaters (ie kuku) were made with various more or less complicated designs on their four faces to produce water-mark designs on the finished cloth. The designs were designated by names; as many as fifty designs are known.
Tapa beater, **70**, 215
colors of, 69
common in Polynesia, 71
how long worn, 38
how printed, 71
Labor employed in making, 71
maker gods, 71
making, 76
making a fine art, 71
making (group), **64**
Manufacture of, 69
Materials for making, **64**
Method of dying, 69
Method of making, **64**
no longer made, 72
patterns and designs, 71
Perfumes for, 71
plants, 217
repairing of, 69
Use of old, 62
Water-proof, 71

Tapas, 57

Tape worms (*Cestoidea*) of many species occur in Hawaii. Almost all species of domestic animals are affected more or less by these parasites which live in the adult stage in the alimentary canal. Dogs, horses, cattle, sheep, swine, and even men have one or more species peculiar to each; in fact, a large majority of vertebrate animals are subject to tape worms. These parasites are peculiar in that they have no mouth nor alimentary canal, absorbing their nourishment from that intended for the host.

Taro and its uses, 65
Cooked, flavor of, 66
Description of plant, 66
Dry-land, 225
flowers cooked, 67
Flower of the, 66
growing, 63
Irrigation of, 270
leaves cooked, 67
plant, Description of, 65
Period of growth of, 65
ponds, 28, 63
ponds, how made, 63
roots, 60
stems cooked, 67
Varieties of, 65

Tarpons, 364

Tassels, Sugar-cane field in, 278

Tattooing was practiced in ancient times to a certain extent. The acrid poisonous juice of Ilieo (*Plumbago Zeylandica*), a small shrub occurring on the lowlands, was used to produce black tattoo-marks. The acrid juice of *Sisyrinchium acre*, from the high mountains of Hawaii and Maui, produced a blue tattoo-mark. Contact with sailors, soon after the discovery of the group, tended to stimulate the art of tattooing. During the early whaling days tattooing the body became very common with the result that almost every old Hawaiian sailor of that period was marked with the conventional designs used by sea-faring men. The practice was not regarded at any time as a religious ceremony (as in certain Polynesian islands), but simply as a matter of personal fancy or sometimes as a token of affection or as an indication of bereavement.

Tatooing, Purpose of, 38

Tattler, Wandering, 310, 323, 321, 324

Tatuing (Tatooing), 38

Taxes, 56
by custom, 56
in olona ,217
payable in, 56
Special, 56

Tea pest, Maui blight the, 385

Tears, Job's, 198

Technical terms, where explained, 9

Tellen shell [Olepe], 456

Temples [Heiaus], 27, 50
Forms of, 50
of refuge, 51

Templeton, W. A., 378

Temperature. The highest shade temperature (U. S. Weather Bureau in Honolulu) in ten years has been 86° Fahr. The lowest 56°. Occasionally on the lowlands a temperature as high as 90° and as low as 52° occurs, but these extremes are rare indeed. Temperature decreases about 1° for each 320 feet of ascent in the mountains.

Temperature in Hawaii, 33

Ten-spotted ladybird, 393

Tent shell, 446

Tentacle. Slender elongated appendages used as organs of touch.

Terebra, 455
shells used for, 455

Termites, 402, 424

Tern(s), 311, 314, 318
Grey-backed, 310
Hawaiian, 310, 316, 323
Noddy, 310
Sooty, 310, 316
White, 310, 318

Terraces (*see* Taro ponds)

Territorial Entomologist, Study of the, 380

Tertiary, 117, 121, 220

Test of sea-urchin, 496

Tetraplasandra (*see* Ohe)

Texas, 378

Text, Arrangement of, explained, 10

Thaanum, Mr. D. (Conchologist), 447, 452, 453, 454

Thatch, Grasses used for, 286

Theft. Thieving was a widespread habit among the Hawaiian people at the time of their first contact with Europeans. Within a few years after the arrival of the missionaries conditions had so changed, however, that valuables might be left unprotected without loss.

The inhabited islands, 100

'The Palms,' 1013 Punahou St., Honolulu, 13

Theobroma (*see* Chocolate)

Thetis, U. S. Revenue Cutter, 95, 304

Thick-bill, Kona, 330

Thimble berry, 258

Thistle, Mexican, 204
Sow, 196

Thrasher shark, 340

Thread-fin, 364
fish [Ulua kihikihi], 366
-waisted wasps, 404, 413

Thrips, 427

Thorax (409). In insects that part of the body situated between the head and the abdomen.

Thorns (203). (*See* spines.)

Thorny amaranth, 196

Thousand-legged worms, 408

Thrum, Thomas G. (Historian and Hawaiian Authority), 12

Thrum, D. F., Photographs by, 14

Thrum's Annual, 12, 155

Thrush [Omau], 334
Chinese, 308
Hawaiian, 334, 331
-like bird, Kauai, 330

Thumbergia, 250

Thwing, Rev. E. W., 433

Ti (*see also* Ki), 210
uses of, 210, 324

Ticks, 400, 409

Tidal wave of 1868, 159

Tide pools in the reef, 488

Tiger cowry, 459
sharks, 345

Tilden, Miss J. E. (Marine Botanist), 402

Tillering plant, Rice an example of, 277
Time of formation of secondary craters (Oahu), 220
Tinder, Fire from, 62
Title page, 7
Titular deities, 49
Toad, American, **384**, 297
Tobacco, 283
Early introduction of, 284
Hawaiian, 284
La Platte, **192**
leaf-beetle, 395
leaf-miner, 423
native of, 284
Toboggan slide at Keauhou, 182
Tomato. The tomato (*Lycopersicum esculentum* Mill.) is a race that has been developed during 200 years of cultivation. It is closely related to the potato and the two can be grafted on each other with ease, although they will not cross. They thrive in Hawaii and are perannual. Species and varieties have been introduced that have run wild, among them the current tomato (*L. pimpinellifolium* Dunal.), a weak plant with small leaves and small currant-like red berries. The cherrie (*L. e. var. cerasiforme* Hort.) or grape tomato with its small red and yellow fruits is common and the fruits are sometimes used for preserves and pickles.
Tomato-fly (Melon fly), 387
Tools, Hawaiian, 74
Topographic map of Hawaii, **148**
Kauai, **104**
Maui, **134**
Oahu, **110**
Topography of Hawaiian Islands, **89-188**
Top-minnows, 378
-shell, **470**, 466
Top spinning was a favorite game with Hawaiian children. The top was made of little gourds called hu.
Torch fishing, 242
Torches, uses of, 311
Torinia, 463
Torpedo bug, 402
shell (Spindle shells), 450
Tortoise, Land (Galapagos), 300
Tortoise shell, 299
fish hooks, 242
scraper [Uhi kahi olona kuakonu], **64**
Use of, 73
Total Inhabitants (*see* Length, Area, Population, etc.)
Total Insect Fauna. Dr. Perkins estimates that the total insect fauna previous to man's interference with nature in Hawaii may have yielded 5,780 species. Of this number something over one-half the species have been collected and described. The total known fauna (1913) is about 3,325. About 1,500 of this number are not regarded as belonging to the natural fauna.
Total land, fresh water and marine fauna of Hawaii has never been estimated. Excluding *Protozoa*, but including native and introduced species from *Porites* to man, there would probably be at least 12,000 species.
Towns (*see* Cities, etc.)
and villages on (*see* Map of island in question, *also* Cities, towns, etc.)
Trade in sandalwood, 219
winds, 31
Traditions of the origin and migration of Hawaiians, 26
Trail, Crest of the Wailau-Mapulahu, **218**
up Haleakala, **134**
Pololo, View from, **218**
Transformation of tadpoles, 299
"Transition" burial, 52
Traps, Fish, **70**, 341
Lobster, 469
Trash fire, Smoke from, **270**
fires, 275
Traveler's palm, **238**, 257
tree, 257
Tree casts, Lava. in Puna, **162**
cotton, 281
fern [Heii], **190**, **194**, 222, 223, 253
-hoppers, 427
melon (*see* Papaya)
moulds, 181
moulds in Puna, **156**
on the shore-line, **150**
rats, 235, 292
snail, attached to a leaf, **220**
snail, Singing of explained, 430
Travelers, **238**
snails, 431
snails, Important genera of, **448**
Triassic, 204
Trigger fish, **370**, 373, 375
Trignometric station on Midway, A, **90**
Triton, Hairy, **460**
Quilted, **460**
shells used for, 450
trumpet, 449
Tritons, 449
Trochus, 463
Tropical almond, 245
America (*see* American continent)
fruits in Hawaii, 255
gardens, Views in, **234**
industries (*see* Sugar, Rice, Coffee, etc.)
Tropics, Symbols of the, 231
Trout, 378
Tropic bird [Koae], **310**
on the nest, **316**.
Red-tailed, nest of, **316**
Tropic Birds, 309
Use of feathers of, 309
True wasps, 414
bugs, 389, 402, 425
Trumpet creeper, 248
fish [Nunu], **350**, 375
Trunk fish [Moa], **374**, 375
Trusses (247.) A compact terminal flower cluster of any kind.
Tryon, G. W. (Conchologist), 464
Tube dwelling bristle-worms (Serpula), **460**
nosed swimmers, 312
Tubes, Worm, 499
Tuber (197). Any thickened portion of the root provided with buds (eyes), as a potato.
Tuff. Fine volcanic products, as volcanic ash, that has become coherent, as by cementation is called tuff, sometimes tufa, though the latter term is more properly applied to cal-

carious materials of a similar nature. In Hawaiian geologic literature both terms have been used in describing tuff cones.
Tuff cone, Diamond Head a, **80**
cone, Sea erosion of, **128**
cones, Small, 115
craters (Oahu), Time of eruption, 121
Tumble-bug (beetle), 417
Tuna, Little, **366**, 361
Tunicates, 484
Common, **490**, 484
Tunnels, Water supply, 127
Tun, Partridge, **460**
shells, 459
Turban shell, **460**, 466
Turkey louse, 400
Wild, 295
Turkeys, 287, 308
Turnstone [Akekeke], **310**, 221, 224
Turret shells, 451
Turtle-dove, Chinese, 305
Turtle, Green, **294**, 300
Hawks' bill, 300
spear, 341
Sea, **294**, 299
Sea eggs of, 300
Fish attached to, 368
Method of capture, **294**
on shore, **294**
Twining (vine) Ascending by coiling about some other object for support.
Two mollusks used as food, **442**
Two-winged insects, 419
Types of mollusca, 441
Typical beach view on a sand island, **96**
Hawaiian children, 32
flies, 419
growth of staghorn fern, **194**
lobelia, **224**
native house of old Hawaii, **28**
native village (Halawa), **140**
scene along a mountain stream, **200**
view in a rain forest, **190**

U

Uala, 284
Uau, **310**
Uhi, **202**, 213
Uses of, 213
Uhu (Parrot fish), **370**, 349, 365
uliuli, 365
Uki, **202**
Ukikiki, 369
Ukiuki, 58
Uku (Snapper), **362**, 349, 371
Uku (Plant), **202**
Ukulele (Flea), 401
(a modern musical instrument), **78**
Ula, 468
Ulaaihawane, **330**
Ulaapapa, 469
Ulae [Lizard-fish], **380**, 349, 359
Ulaula (Snapper), **362**, 349, 371
Ulehihi, 213
Uli. The chief god of sorcerers was Uli, although this class worshiped numerous other deities. The class of lesser demons were chiefly females, as the reptile goddess [Kiha-wahine], the goddess Hiiaka, etc. Certain shark gods were also worshiped by sorcerers.
Ulili, A bamboo flute (*see* plate 5, fig. 1)
(Wandering tattler), **310**
Uliuli hula (rattles), **70**
Ulu (Breadfruit), **258**, **264**, 239, 241
Native use of, **80**
stones, 83
Ulua (Cavalla), **362**, 349, 364
kihikihi (Thread fish), **366**, 349, 364
Uluhe (Staghorn fern), **194**, **228**, 223
launui, **228**
Ulukaka=Ulu
Ulumaika, **57**
Uluna (a pillow). They were made of lauhala or of very light wood as wiliwili, etc.
Uluna, **57**
Ulva sp. (fig. 4), **492**
Umbrella shell [Opihi kapuailio], **460**, 467
plant, **234**
tree, 244
Umbillical cord. The cutting of the umbillical cord was attended by important religious ceremony.
Umbilicus defined, 462
Umeke. A calabash usually used to contain poi and then called umekepoi
Umeke (*see also* calabash), **57**, 59
Umekes (bowls), **57**, **70**
in nets [Koko], **57**
Umoki. The stopple for a water gourd. The shell of one of the marine *Terebra* spp. was commonly used as a stopple.
Unaoa. The barnacles found clinging to the hulls of vessels.
Underground water, 127
Undershrubs, Characteristic, (Middle forest), **200**
Unicorn fish, 372
Unisexual [Bot.] (217). Flowers having either stamens or pistils only.
United States, 242, 259, 262, 276, 284, 360
Exploring expedition, 477
Fish Commission, 351
Univalve explained, 447
Unloading sugar-cane, **278**
Unukane (Wedge-tailed shearwater), **327**
Upena hehe, 341
kuu (Long sea net), **344**
poo, 341
pua, 341
uhu, 341
Upi (sponge), Common, **494**
Upland cotton, 281
ranch on Hawaii, **282**
Upper falls of Moaula, **140**
forest zone, 227
Urchin (Sea-urchin), **496**, 487
Heart, **496**
Rough-rock, **496**
U. S. Experiment Station (*see* Hawaii Agricultural Exp. Station)
U-u (Squirrel-fish), **362**, 349, 371
Uulai, Use of, 215
Uuna. The shell of a tortoise.
Uwekahuna, **184**, 183

V

"Vacation Island," The (Molokai), 140
Valley(s), on Kauai, 104
on Hawaii, 148
Isle, The, Maui, 237
on Oahu, 110
Principal, on Maui, 134
Value of sugar crop (*see* Sugar production)
Valve (445). One of the two shells of any clam-like animal.
Vancouver, George (Navigator), 153, 219, 263, 267, 289, 295
Vapors from Halemaumau, 166
from Mokuawoewoe, 186
Variation, Color, in land shells, 432
Variation (433). Departure from the normal.
Variation, Example of (shells), 435
of flora, 193
Plant, Causes of, 193
Shells, Example of, 433
Varieties (*see* Nomenclature)
Color, 433
Various animals from land and sea, 291
Varnishes, gums, paste, etc. The natives made varnish of kukui bark, banana buds and ki leaves; paste of ama'uma'u; gums of the breadfruit juice.
Vaughan, Dr. T. Wayland (Geologist, Zoölogist), 477
Vein [Bot.] (215). The small branching ribs forming the framework of the leaf.
View(s) across Hanauma Bay, 128
in a forest jungle, 200
in an ohia forest, 200
in Honolulu gardens, 240
Government Nursery, 238
in Kilauea, 174, 184
in Leper Settlement, 136
in Nuuanu valley, 112
in Olokele cañon, 106
in the forests, 200
in the Koolau range, 112
in Tropical gardens, 234
in Waimea cañon, 106
near the Pali, 112
of Halemaumau, 166
of Honolulu aquarium, 356
of Lanihuli peak, 112
on Ocean Island, 90
showing bog flora, 218
Vegetable flies, 421
fly (Melon fly), 387
Vegetable Oils. Wrestlers used the oil from kukui nuts to make their limbs supile and render the body slippery. (*See* Oil.)
Vegetation along the streams, 200
at Kilauea, 166
in a wet forest (figs. 2, 3), 190, 200
in Kilauea, 170
in Kilauea-iki, 170
in the forests, 200
on Hawaii, 156, 160
on Konohuinui, 224
on Midway, 90
on mountain ridges, 218
Sulphur fumes, effect on, 170
Ventral fins (368). Fins on the ventral side of the body corresponding to the hind limbs in other animals.
Venus clam, 456, 446
Verbena, 205
Vermifuge, Papaya seeds as, 263
Vertebrates (299). The great group of animals provided with a jointed spinal column.
Vertical section through Diamond Head, 118
Vessels, Birds following, 312
Villages and towns on Kauai, 104
and towns, Principal, on Hawaii, 148
Typical ,on Kauai, 102
(*see* Cities, etc.)
Vinca, 207, 250, 254
Vine(s), and shrubs, 248
Bird-claw, 250, 248
Festooning, 234
Fire-cracker, 250, 248
Fruiting, 248
"Museum"=Bird-claw vine, 250
"Stick tight"=Bird-claw vine, 250
Vinegar-fly, 421
Violet aphis, 389
Chinese, 248
Mahukona, 199
Native, 229
snail, 470, 463
Viridonia, 332
Viscid (217). Sticky. Having a glutinous surface.
Volcanic Bombs. Masses of lava that have solidified into more or less rounded masses in the crater and are hurled out as *bombs*. Specimens occur at various places in the group, as Palolo crater, Haleakala, etc.
Volcanic craters, Active, 101
craters, Extinct, 101
glass (*see* Obsidian)
islands, The, 101
sand, 117
Volcano House, distance from, to important points (*see* Overland Distances)
House, Elevation at, 166, 165
House, Fern jungle at, 194
House, Fireplace in, 184
House, Halemaumau from the, 166
House, Staghorn fern near, 194
-made scenery (Haleakala), 145
-made scenery on Hawaii, 162, 156, 160, 166, 170, 174
Volcanoes on Hawaii indicated, 148
Work of Hawaii's, 163
Voracious (361). Taking food in large quantities.
Vowels, Hawaiian, 39
Vows were usually made and kept by Hawaiians—through fear of their gods. A vow once made was regarded as a very sacred engagement.
Vulcanology, Oahu a laboratory in, 109

W

Waa. A canoe. The ancient Hawaiian canoes were dug out of a single koa log. Among the specific names were waa kaukuhi=a single canoe; waa kaulua=a double canoe; waa pelelua=a blunt canoe.

Waa (outrigger canoe), **80**
Wad cutting bee, 415
Wahiawa, 114, 132
plain, how formed, 220
Wahine noho mauna, **228**
Wai. A general name for that which is liquid; fresh water as distinguished from salt water (kai). A word with many compounds.
Waiahole tunnel, 127
Waialae Bay, 211
Bay, Fresh water springs at, 131
Waialeale mountain, 103
Waialua Bay, 211
Waialua orange (*Citrus Aurantium sinensis* Engler). This is the common sweet orange of wide cultivation. It is known as the 'native orange,' though it was doubtless introduced by Vancouver..
Waianae mountains, **122**, 211
mountains, Age of, 124, 213
mountains, Early appearance of, 220
range, 132
range, Erosion of, 122
range, Gneral view of, **122**
Waihee valley, 138
Waikiki, Animals to be collected at, **116**
beach, **80, 116**
Common algæ at, **492**
Common marine plants at, **492**
Common sea moss at, **492**
Coral reef at, 131
Diamond Head from, **116**
Palms at, 233
Plants at, **116**
Surf at, **80**
Wailau valley, 133
sea-shore at, **136**
Wailua Falls, **102**
stream, **102**
valley(Kauai), 107
Wailupe valley, 129
Waimanu valley, 149
Waimea Bay, Oahu, Surf at, **128**, 211
cañon, **106**, 107
on Hawaii, 149
Wainiha valley, 107
Waipio valley, **154**, 149
valley, Erosion of, **154**
evidence of a drowned valley, **154**
General view of, **154**
Rice fields in, **154**
Scenery of, **154**
Water fall in, **154**
Waipuhea (Blown water) falls, **112**
Waistband, **57**
Wakea, 50
Walahee (*see* Alahee)
Waldron's ledge at Kilauea, **170**, 179
Wallace, Alfred Russel (Evolutionist), 94
Walled enclosure (Mullet ponds) ,**270**
Walls of Kilauea (shown), 184
Walsingham (Lord), 420, 422, 423
Walu, 349
Wana, 487
Wandering tattler [Ulili], **310, 323**, 321
Warble-fly, 387
War canoe, **48**
councils, 50
Influence of, 34
War months. The five months following January [kaelo] were war months. During the remainder of the year there could be no war.
Warfare, 50
at certain seasons, 79
Canoes used in, 51
Captives in, 53
Fatality from, 53
Implements of, 79
Method of, **84**, 47
Peace after, 53
Recruits for, 51
The challenge in, 53
The dead in, disposition of, 53
Termination of, 54
Use of forts in, 51
Use of idols in, 53
Women's part in, 51
Wargods, **52**, 77
gods kept by priests, 54
Warren, J. T., Photographs by, 14
Warrior, Hawaiian, **44**, 51
Washington, Dr. H. S. (*see* Hawaiian Igneous Rocks)
palm, **246**, 237
Wasps, 404, 412
Common, **406**
Digger, 413
Experiments with, 415
Keys to species of, 414
nests made of, 404
Water beetles, **436**, 416
bottles, Stoppers for, 61
Buffalo, **282**
cress, 208
fall in Waipio valley, **154**
falls [Akaka] (500 ft.) on Hawaii, **162**
falls along the coast (Hawaii), **154**
falls on Kauai, **102**
falls on Molokai, **140**
falls on Oahu [Waipuhia = Blown water], an intermittent fall near the Pali, **112**
falls (*see* name of falls in question)
-glass for collecting, **478**, 476
-lemon, 268
-lemon, Purple, **258**, 268
-melon, 269
-nut (*see* Chinese Horned-nut), 285
-proof tapas, 71
scavenger beetles, 416
supply tunnels, 127
Waterboatman, **436**, 426
Wattle, 248
Black, 248
Silver, 248
Wauke, 69, 217
Wauki (*error see* Wauke)
Wawae iole, **214**
Wax plant, 248
Weathering, Examples of, Molokai, **136**
Example of (The Pali), **125**

Weaver birds, 277, 304
Wedge work, done by guava, 263
-tailed shearwater, **310, 316, 327,** 312, 313
Weed, Jamestown, 287
Jimson (Jamestown weed), **198**
Poisonous, 341
Weeds, 286
Common, **196**
"Weeping" palm, 237
Weevils, 395, 405, 418
Weke, 373
ula [Surmullet], **362,** 373, 349
ulaula (Surmullet), **366**
Weli. The name given to the curious worm-like Holothurian at Pearl City, Kaneohe, etc.
Welling of liquid lava, 168
Wells (*see* Artesan wells), 127
Well-to-do, Houses of the, 58
West Indies, 211, 232, 244, 252, 262, 266, 296
Wet forest, Vegetation in (figs. 2, 3), **190, 200**
Whale, A race for a, **298**
Arctic right, 301
Boat fast to a, **298**
Whalebone, 301
Capture of, 303
Humpback, 301
in the Bishop Museum, 302
ivory, 302
ivory, use of, 79, 302,
'Killer,' 346
-lice, 468
oil, 302
Right, 301
Sperm, **298,** 301
Whaleboat, **298**
Whalebone, Yield of, 303
whale, 301
Whales, 301
and whaling scenes, **298**
attach by Orca, 347
food of, 301, 302
Size of, 301
'Soundings' of, 303
teeth, use of, 82
Whaling industry, 301, 303
Whaleship, Full-rigged, **298**
stripping off "blubber," **298**
Whelks, 441, 450
When introduced (*see* species in question), 296
Whetstones [pohoku hookala], 75
(*see* Grindstone)
White ants, 402, 424, 425
ant, Hawaiian, 425
-breased albatross, 312
cabbage butterfly, 422
mice, 293
mulberry, 267
potatoes, 284
rats, 293
-tailed tropic bird, 309
tern, **310,** 318
Wi (Shell), **470,** 466
Wi (Fruit), **264,** 266
Wicker-work basket [Hanai poepoe], **57**
for helmets, 77
Wide ranging shore forms, 195
Width of channels (*see* Inter-Island Channels)
of various islands (*see* Length, etc.)
Wild bananas, **190**
cats (Introduced), 293
euphorbia, **196**
fowl, 308
fruits, **258**
geese (foreign), 328
geranium, 287
goats, Damage by, 221
Ipecac [Nuumele], **212**
rice, 277
strawberry, 255
Wilder, William (Collector of Mollusca), 12
Wiliwili, **194,** 203, 210, 395
Native use of, **80,** 204
The so-called, 203
wood, use of, 86
Wilkinson, John, 279
Wikstrœmia (*see* Akai)
Williams, James J., Photographs by, 14
Wind blown sand on Oahu, **122**
Erosion by (sandstone), **142**
gap, The Pali, example of, **125**
Winds, Trade, 31
Windward Islands, 93
side of Oahu, 131
Window flies, 419
Wine-jar shells, 459
Wine palm, **246,** 237
Wingles bird-lice, 430
bird, So-called, 318, 333
Winter (*see* Hoilo)
Winter visitors (ducks), 328
Wire grass (Dog's tail), **196**
-worm, 399, 417
Woman, Status of, 46
Women, Certain duties of, 46
Medicine practiced by, 46
in times of war, 51
Special tabus for, 46
dress, The Hawaiian, 38
work, Mat making, 73
Wood, bone and stone, uses of, 75
-borer beetles, 417, 418
cabinet, 213, 245
Implements of, 74
of tamarind, how used, 245
sorrel, Yellow, **196**
Wooden calabashes [Umeke], 57
idol, **52, 70,** 49
image, **70**
tapa anvil, **64**
Wood-louse, 408
Wood-peckers. There being no native wood-peckers their introduction has been repeatedly urged to cope with the koa tree borer and other insects injurious to the Hawaiian forest.
Work of Hawaii's volcanoes, 163
sugar-cane borer, **380**
Worm, Black cut, 422
Book, 418

Cabbage, 399
Flat, **490**
-like animal, 484
-like sea-cucumber, 495
Marine, **490**
shells, 462
shell [Pohokupele], **460**
Ship, **490**
Sweet-patoto horn-, 399
tubes, 499
Worms, 491
Bristle, 497
Cabbage, 422
Flat, 497
Sea, 497
Tape- (*see* Tape-worm)
Thousand-legged, 408
Worship, Idol, 49
Objects of, 49
Wreath, Purple, 248
Wrasse-fishes, **366, 370,** 359, 365
[Hilu lauwili], **370**
[Omaka], **366**
[Opule], **366**
Wrays, Batavian cane, 273
Wreath, Purple, **250,** 248
Wrestling, 83
Wrigglers (defined), 419

X

Xylosma (*see* Maua)

Y

Yam(s) [Hoi], 67, 213
uses of, 213
Yellow canaries, 320
Bignonia (Bird-claw vine), **250**
dragon-fly, 424
fever spread by, 387
-head [Ou], **337**
-headed ou, 331
jackets, 404, 414
oleander, 252
Otaheite cane, 273
poinciana, 244
-shouldered ladybird, 393
-tufted honey-eater, **330**
wood-sorrel, **196**
Yield per acre of sugar-cane, 271
Yokohama, Route from to Hawaii, **100**
Young, Care of (*see* species in question)
Hawaiian, **80, 84**
Laysan albatross, **316**
Yosemite, Iao compared with, 138

Z

Zamia, sp., **246**
Zebra dove shell, 453
dove shell, **470**
Zizyphus (*see* Jujubi)
Zones, Floral, 195
Lowland, 195
Lowland, 201
Lower forest ,210
Middle forest, 222
Upper forest, 227
Second plant, 201
Zoophytes, 480

FEB 18 1916